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ALTERNATIVE MOTOR VEHICLE FUELS

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

ALTERNATIVE MOTOR VEHICLE FUELS

JUNE 8, 1989

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ALTERNATIVE MOTOR VEHICLE FUELS

THURSDAY, JUNE 8, 1989

U.S. Senate,
Subcommittee on Energy Research and Development,
Committee on Energy and Natural Resources,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:02 p.m., in room SD-366, Dirksen Senate Office Building, Hon. Wendell H. Ford, presiding.

OPENING STATEMENT OF HON. WENDELL H. FORD, U.S. SENATOR FROM KENTUCKY

Senator Ford. Good afternoon, ladies and gentlemen.

This afternoon the subcommittee is holding a hearing on alternative motor vehicle fuels. We will be talking about alternatives to the use of gasoline. Thirty-nine percent of our oil use is in the form of gasoline. It is the hardest part of our oil consumption to control. We are a mobile society. We need our cars, and we like our cars.

Any serious program for energy independence has to deal with the consumption of gasoline. We need to use gasoline more efficiently in the near term through more efficient automobiles. But eventually we will have to look for alternative fuels for transportation. We need to look at transportation based on natural gas, coal and ultimately on electricity.

The principal alternatives that we will discuss today are methanol made from natural gas or from coal, ethanol made from corn or other vegetable matter, and natural gas which, when compressed, can be used to operate motor vehicles.

I congratulate Senator Rockefeller who urged us to have this hearing, and shortly he will chair the balance of the hearing. He was the author of legislation in the last Congress, with Representative Phil Sharp, designed to encourage the development of automobiles capable of using methanol. The purpose of the hearing today is to get a status report on the development of alternative fuels and to receive advice as to what the next steps are in encouraging the use of these fuels.

With Senator Rockefeller's assistance, we have assembled a distinguished panel of witnesses today, and I look forward to reviewing the record that we make here.

Senator Burns, do you have any statement you would like to make?

STATEMENT OF HON. CONRAD BURNS, U.S. SENATOR FROM MONTANA

Senator Burns. Thank you, Mr. Chairman. I certainly do, and I want to first thank the distinguished panel members for attending today and would like to express my appreciation to the Chairman for holding these hearings. And, of course, Senator Rockefeller who has been, as the Senator from Kentucky has stated, a prime mover in this.

Mr. Chairman, at a time when the United States is importing more than half of its petroleum needs, it is clear that the reliance seriously jeopardizes our national and energy security needs. While we must take the initiative to develop the petroleum resources we have in this country, we must also determine the role of alternative fuels as an energy supplier.

The use of alcohol fuels is not a new concept. In fact, during the 1940's alcohol was used by a number of countries that were experiencing shortages as a result of World War II. The interest eventually died out and was revived only by the energy shortages of the 1970's.

The passage of the Energy Tax Act of 1978, which included exemption for fuels containing 10 percent or more alcohol from Federal excise taxes on gasoline, stimulated the growth of a substantial alcohol fuels industry. From a production level of 210 million gallons in 1982, the level has reached 810 million by 1987. More importantly, sales during this time frame exceeded domestic production clearly indicating that there is a market available. Of course, there is always a market available at a price.

Not only should we look at alternative fuels in the context of its value of increasing our energy independence, but consideration must be given to the positive impact these fuels have upon the environment. Studies show that the use of alcohol fuels, such as ethanol, reduces the amount of carbon monoxide released into the atmosphere. The health standards for carbon monoxide and the ozone are exceeded in most urban areas. Targeting the use of these fuels to these areas will significantly curtail dangerous carbon monoxide emissions.

Montana wheat and barley would provide an excellent source for the production of ethanol fuels. In fact, we have two plants operating in the State now.

Mr. Chairman, Montana has the largest coal reserves in the United States and a substantial supply of timber. The potential use of methanol produced from coal and timber represents an enormous benefit to my State, as well as for the entire country. Currently methanol is produced almost entirely from natural gas. The vast majority of this gas comes from foreign sources. Turning our attention to the use of domestic coal and timber for methanol production makes sense from an economic as well as a security standpoint.

Mr. Chairman, there is a number of variables that must be considered in the production of alternative fuels. And I look forward to hearing the testimony here this afternoon and to working with this committee in developing some alternatives that would be beneficial to this country.

Senator FORD. We are very pleased today to have the ranking member of the Energy and Natural Resources Committee, the Senator from Idaho, Senator McClure. Senator?

STATEMENT OF HON. JAMES A. McCLURE, U.S. SENATOR FROM IDAHO

Senator McCLURE. Thank you very much, Mr. Chairman. I have a brief statement. I want to focus on just a couple of issues, not cover the entire area.

Our continued national reliance on the automobile for our principal source of transportation has significant energy and environmental implications for all Americans. During recent hearings in Los Angeles, the committee received testimony from State and local officials on the impact of our reliance on the automobile on Los Angeles air pollution and on global climate change. A few days later in Albuquerque, the committee received further testimony from expert witnesses on the energy efficiency and environmental benefits to be derived from a shift to alternative transportation fuels.

Success in our quest to find alternatives to gasoline as our transportation fuel can serve as an important and critical element in our national energy strategy for the reduction of oil imports. Besides gasohol, studies by the California Energy Commission indicate that several alternative transportation fuels offer the benefit of lower environmental impacts and, in particular, lower effects on global climate change compared to gasoline. Among these alternative fuels are ethanol, diesel, compressed natural gas and methanol from natural gas. Each alternative fuel has its own unique characteristics and customer acceptance.

Since the gasoline lines of the 1970's, the Department of Energy has examined several alternatives to extend or replace gasoline supplies. Among these, alcohol fuels has received the most attention as either a neat fuel or in low concentration blends with gasoline. Since Federal economic incentives were provided in 1978 for the production and sale of ethanol, sales have continually climbed. In 1988, 8 percent of all gasoline sold in the United States was a 10 percent gasohol blend. About 320 million bushels of corn were consumed annually to make this ethanol. This is not only good for our national energy security and environmental quality, but it is also good for our Nation's farmers. It seems to me that we can kill not two but three birds with one stone.

Our options, of course, are not limited to the alternative fuels alone. Energy and environmental benefits also can be achieved from certain fuel additives, in particular, oxygen enhancers such as methyl tertiary butyl ether from methanol and a new product made from ethanol, ethyl tertiary butyl ether, or ETBE. Such oxygenated additives not only reduce emissions of carbon monoxide, ozone and air toxins, but improve automobile fuel economy as well.

Alcohol fuels have also been an important alternative to extend available gasoline supplies. Over the years, this Senator has supported Federal tax incentives for alcohol fuels. During the last Congress, I also supported enactment of the Alternative Fuels Act of

1988 which authorizes a modest Federal program to foster markets for alternative fuels. But this is not all we can do.

This brings me to a point of concern and that is why are existing Federal tax credits for blender fuels not also available for ETBE. ETBE is a superior gasoline additive derived from renewable ethanol. This past Tuesday during discussions with the President on his pending decisions on clean air legislation, I in fact discussed this concern. The President assured me that this issue would receive his early attention.

Over 75 Senators and three cabinet members—that is, EPA Administrator Reilly, Secretary Watkins and Secretary Yeutter—support this clarification of the application of the blender tax credit to ETBE by the Treasury Department. This simple action could significantly serve to enhance air quality in many major cities. The infrastructure exists so that commercialization can occur immediately with an accompanying reduction in America's dependence on foreign oil.

Because of this concern and my support for greater use of alternative fuels, I look forward to hearing today's testimony and the other testimony that this committee will derive.

Thank you very much, Mr. Chairman.

Senator FORD. Thank you, Senator McClure. It's an excellent statement. It seems like you are always ahead of the curve. One of these days we will be able to catch up with you.

I said earlier that this hearing today is made possible through the hard work of the distinguished Senator from West Virginia, Mr. Rockefeller. I think the crowd that we have today indicates not only the interest in the subject, but interest in the fine witnesses we have. So, with that, I want to turn the gavel over to Senator Rockefeller. He will chair this hearing because he deserves the credit for what we are doing today, and without further ado, Senator, if you will come and take my chair, we would be delighted for you to make your statement and to proceed with the first witness.

I wish to submit for the record a statement by Senator Bingaman.

[The prepared statement of Senator Bingaman follows:]

STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

Mr. Chairman, I want to thank you for scheduling this hearing on a subject important to all Americans. Also, I wish to commend Senator Rockefeller for his leadership in encouraging the commercial use of alternative motor vehicle fuels.

This hearing is providing an important forum to consider the next step in promoting alternative fuels. Senator Rockefeller's legislation from the 100th Congress contributed greatly to that effort.

Last month, I introduced legislation that is an appropriate follow-up to Senator Rockefeller's initiative. My bill, S. 1058, the Clean Air Fuel Conversion Act, would help build a market for alternative fuels by gradually converging portions of the federal fleet from gasoline to cleaner-burning fuels, such as methanol, ethanol, propane, natural gas and electricity.

These fuels can dramatically reduce emissions of both carbon monoxide and the hydrocarbons that contribute to our ozone and particulates problem. The current high levels of pollutants in non-attainment areas are a serious threat to public health and the environment.

S. 1058 would require federal fleets operated in serious or severe non-attainment areas to convert vehicles to cleaner, alternative fuels at a rate of at least 10 percent a year, beginning in 1993. The Postal Service is exempt from the legislation, but the military is not.

The bill also should increase the availability and use of alternative fuels and technologies, and encourage American auto manufacturers to step up their production of alternative-fueled vehicles. The legislation creates a guaranteed market with government fleets that should, coupled with Senator Rockefeller's measure, give the auto industry the necessary incentives to develop and produce cleaner cars.

Congressman Vic Fazio of California has introduced similar legislation in the House. I would ask both my colleagues on the Energy Committee and my friends at the Energy Department to consider supporting S. 1058.

As I see it, there are three key benefits to the increased use of alternative fuels. First, we can reduce our steadily growing dependence on foreign sources of crude oil. Second, we can trim farm subsidies by creating a market for alcohol fuels from agricultural products. And third, we can help rising emissions of carbon monoxide and ozone that threaten public health and safety.

Late last month, my Subcommittee on Mineral Resources Production and Development held a field hearing in Albuquerque on the relationship between alternative fuels and clean air. Hearing the testimony there, I became even more convinced of how high the stakes are on this issue. But I am confident we will make more progress in the 101st Congress because I know these initiatives will receive full consideration here in the Congress and in the Administration.

I look forward to reviewing the testimony of today's witnesses and pledge my efforts to seek solutions to one of our chief environmental problems—vehicle emissions.

Thank you, Mr. Chairman.

Senator McClure. While the Chairman is taking his chair, I might also explain that we have natural gas decontrol legislation on the floor and that kind of divides my interest. I will not be able to stay for the hearing because of that.

Thank you.

Senator Burns. I would echo that.

Senator Rockefeller. Well, I'm going to be right here.

Senator Ford. We'll vote you.

Senator Rockefeller. Okay. [Laughter.]

STATEMENT OF HON. JOHN D. ROCKEFELLER IV, U.S. SENATOR FROM WEST VIRGINIA

Senator Rockefeller [presiding]. I would like very much to make a statement, and so I will.

I hope that today, in fact, that we begin a rather new phase in congressional action on alternative fuels and energy policy. I very much thank Chairman Ford for convening this hearing and for his overall leadership in all areas of energy policy and the direction that they need to be taking in this country.

Last year, as everybody knows, we enacted the Alternative Motor Fuels Act, a bill that provides fuel economy credits as incentives to auto manufacturers to produce cars that can run on methanol, ethanol and natural gas. That was, however, only the first step in promoting the use of alternative motor vehicle fuels. Much more needs to be done, and that, as far as I am concerned, is part of the business of our hearing today.

We are here today to look at not only the automobile, but the production plant and the fuel pump and the other elements of a new alternative fuels transportation system. We are here today to find out what government and what the private sector can do together to make such a new system a reality.

Our energy security requires action with oil imports of nearly 7 million barrels a day, over 40 percent dependent on imports. In

1987, cars and trucks used the unbelievable and, as I would say, obscene 128 billion gallons of gasoline, all of it of course deriving from oil.

We have deluded ourselves into thinking that reliance on imported oil is a cheap policy. In 1987, oil from the Persian Gulf sold for $16 a barrel, but that was not its cost, in fact. The military cost of reflagging and other operations to protect the flow of that oil from the gulf was over $14 billion, and thus in that year the average cost of a barrel of oil was $52, the actual real cost.

The assumption that we can stay dependent on imported oil because it seems to be cheap will be a very expensive assumption in the long run. As Secretary of Energy Watkins has said recently, we must do something about the danger signs, and time is running out.

Additionally, we face a growing smog emergency in many of our cities. It seems to me most of our cities. State and local officials, as well as environmentalists, tell us that moving to alternative fuels may be one of the most significant things that we can do in taking action for cleaning up the air.

And finally, I believe we must begin to bring back to this country the lost wages and the lost jobs resulting from the decimation of our energy industry during the last 10 years. Alternative fuels such as methanol, ethanol and natural gas can be an important element in reviving our domestic energy industry.

All of this will take time, and we understand that. And we are all aware that there are many technical and political obstacles to success. But that is why we are seeking the broad advice of the spectrum of public and private experts. We must marshal our talent and resources, and we must meet this challenge.

We need to start today to think systematically about what can be done to make alternative fuels a major component of our national energy policy, of our national transportation policy and of our national environmental policy. We need to address issues on a variety of fronts, including production of alternative fuels, distribution of alternative fuels, use of alternative fuels.

We need to think systematically about what can be done in the next 10 years or so to displace millions of barrels of oil a day, imported oil, with alternative fuels. It is time for us to get on with the job of making the United States energy secure again. And to help us to do this, we have a very distinguished witness panel, and I look forward to their testimony.

And I will add another note. There will be much reference made today to whatever it is that the President will propose on Monday of this coming week. No matter what he proposes about clean air or whatever, there are many other issues that need to be addressed. The time for delay is past, and waiting for others to make decisions is not a good way to get things done in this country.

Our first witness is one of my favorite people, Chuck Imbrecht, Chairman of the California Energy Commission from Sacramento. Chuck, I welcome you and look forward to your testimony.

STATEMENT OF CHARLES R. IMBRECHT, CHAIRMAN, CALIFORNIA ENERGY COMMISSION

Mr. IMBRECHT. Thank you very much, Mr. Chairman. And let me begin by offering a couple of parenthetical comments.

I must say that I am exceedingly encouraged by the tone and tenor of the comments of each of the members of this committee in their introductory remarks.

You obviously deserve the broad recognition and credit for initiating the effort to pass the Alternative Motor Vehicle Fuels Act last year, and I want to once again express on behalf of the people of California our appreciation for your efforts and assistance in that regard.

But secondly, I would like to just call attention to the fact that we have heard from two members of each party this afternoon. Each expressed the kind of broad bipartisan consensus that has similarly developed in Sacramento.

California today has the most aggressive alternative motor vehicle fuels program in the Nation as a result of legislation that was passed by a democratically controlled legislature and initiated by a Republican administration.

I would suggest that that kind of growing bipartisan consensus that is evident here in Washington as well in the context of the suggestions that I am encouraged by that seem to be coming forward from the President's administration, as well as the kind of consensus that has developed in Sacramento, suggests to me that it is time that we once again extend an invitation to those that would seek to perpetuate the status quo to work with us in a constructive fashion to ensure that we not only can meet the energy security needs of our Nation, but also dramatically improve our environmental quality.

We began our program in California many years ago principally focused on energy security.

Let me put California's consumption in a little perspective. Today we are the third largest consumer of gasoline in the entire world exceeded only by the cumulative United States and the Soviet Union. The State uses on average more than 1 billion gallons of gasoline per month, and its transportation system is 99 percent dependent on petroleum-based fuels.

With expectation that crude oil imports will exceed 50 percent of our total demand of the United States by the early to mid-1990's, it seems quite apparent to us that we must pursue a policy of increased diversity in order to build an insurance policy, if you will, against the kinds of supply disruption threats and economic uncertainty that affected not only our State, but the rest of the country during the 1970's.

Aside from energy security, even with the most aggressive program to combat air pollution in the United States, our major urban areas still do not meet Federal air quality standards. In the Los Angeles area alone, for example, the Nation's highest unhealthful levels of ozone persist for most of the summer months. In 1988, in this area, the Federal ozone standard was violated 176 days, and on the worst day, peak ozone was three times the allowable level.

Recently a report by the California Air Resources Board listed 25 candidate or previously identified toxic substances which are known or suspected from emissions from gasoline and diesel motor vehicles. As lead was phased out of gasoline for obvious health reasons, other hydrocarbons such as benzene were added to regain lost octane. This report estimates that benzene in gasoline and diesel particulate emissions now account for over 60 percent of the cancer risk associated with motor vehicle use in California. I think that is a sobering statistic and one that we ought to certainly take into context as we discuss alternatives available in each of those policy arenas.

With post-combustion pollution controls reaching a level of diminishing returns, it seems clear to us that cleaner alternative fuels must be used to help improve California's energy security and reach our air quality goals. Moreover, in the context of global warming, I think it is important to note that the broad range of alternative fuels, which we have focused our efforts on and which you have as well, would result in a smaller greenhouse impact than continued use of gasoline.

We believe that methanol is likely to have the broadest application for a variety of reasons. First, it is a clean-burning, liquid alternative that can easily substitute for both gasoline and diesel. Second, it is the least disruptive alternative for consumers, automotive companies and the fuel distribution industry. And last, it provides equal or superior vehicle performance in all applications.

I want to make it clear at the same time, however, that we do not believe that methanol is a panacea, that it alone is going to solve our air quality problems. It must be part of an integrated approach and strategy that also embraces a broad range of other alternate fuels technologies. It is clear that even with today's technology, there are suitable economic and very desirable applications for other fuels, such as ethanol, compressed natural gas and electric vehicle technology as well.

Given the conventional chemical demands for methanol, we fully recognize that additional supply will be necessary if we are to see a transition to substantial use of as an alternate motor vehicle fuel.

We are also aware of the concerns that have been expressed by some that much of the world's natural gas reserves are in the same region where we must import much of our petroleum supplies from. However, I think it is important to note that because of the broad range of other countries throughout the world that also have large natural gas reserves, it is clear that we will broadly diversify the potential supply sources for fuel in the United States and thereby substantially mitigate against the opportunity for an OPEC cartel arrangement such as that which affected us in the 1970s.

And let me just note that the U.S. Department of Energy in a recent report entitled "Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the United States Transportation Sector" reaches similar conclusions.

I should also note for you that we have engaged in a broad, cooperative study with the private sector, known as the California Fuel Methanol Cost Study, which projects capital costs of new methanol plants in various locations in the world. While I fully appreciate—

and you will likely hear arguments relative to other assumptions in order to calculate a final price—let me simply suggest to you that we believe that with reasonable, middle range estimates, it is clear that methanol will, in fact, likely be cost competitive with gasolines as we know them today or as they are likely to be regulated in the future, and moreover that it represents a cost effective, long-term clean air strategy as well.

The above costs analysis is also consistent with the commission's own market penetration scenario for methanol fuel as a direct competitor with premium gasoline. With the cost projection equivalent to high octane gasoline and yet offering an octane rating that is 10 points higher than premium gasoline, methanol M85 fuel could easily become the consumers' choice from a performance standpoint. The increased performance is even distinctly apparent in fuel flexible vehicles, let alone in an optimized engine application.

But let me turn also to the implications for air quality. Although some are still suggesting that air quality benefits of methanol are overestimated or uncertain, testimony provided to the California Air Resources Board, the South Coast Air Quality District, and the Governor's Board on Air Quality and Fuels indicate that widespread use of methanol fuels will have a significantly positive impact.

Based on the results of a study conducted by Carnegie Mellon University, we calculate that mobile source peak ozone levels could be reduced in the south coast air basin from between 29—and that is the pessimistic case—to 69 percent—and that is the M100 case. With the latest data from emission tests from California's fuel flexible vehicles, the ones we have in operation today, the likely peak ozone reduction level would be at least 50 percent.

And while the ozone benefit will be also retained in multi-day episodes, I think it is important to note this is not the only benefit because the authors of a study conclude that there also would be simultaneous benefits in vehicle emission reductions of particulate matter, oxides of nitrogen, atmospheric concentrations of benzene, PAN, which is an eye irritant and a plant toxin, and of course, nitric acid, which is an acid rain constituent.

The benzene reduction, as I indicated, is particularly important since this compound is a known human carcinogen. And again, I would reiterate that it, in conjunction with particulate matter from diesel emissions, represents a very significant portion of cancer risk with respect to motor vehicle emissions in our State.

Finally, let me just note that with respect to formaldehyde, while it is clear that tailpipe emissions from a methanol vehicle do result in higher emissions at the source, because of the lower reactivity of the hydrocarbons of methanol, the atmospheric formation of formaldehyde is actually reduced. And, indeed, the same Carnegie Mellon study indicates that in 1993 with the standards we have already adopted through the Air Resources Board for formaldehyde emissions which are comparable to gasoline cars, the actual atmospheric exposure to the public would be reduced 13 to 17 percent.

Senator ROCKEFELLER. It is a coincidence, isn't it, that those who are not interested in methanol only refer to tailpipe emissions when they are talking about formaldehyde?

Mr. **Imbrecht**. Well, I think it is obviously a function of selective use of information, and it is critical that we think about what we are actually breathing and that is the atmospheric level associated with any contaminant that we must be dealing with.

The authors of the study also point out that this decrease occurs as a result of the displacement of gasoline and diesel emissions which at present would have been transformed, as I said, into higher formaldehyde in the atmosphere.

In terms of safety, there are arguments on both sides, but let me make it clear that there are many attributes of methanol that are superior to the conventional fuels we use today.

In an open spill, methanol is less flammable because it has a higher ignition temperature. This is obviously one of the reasons that it is used in the Indianapolis motor racing industry. And if you had a chance to watch the race, you might have noted that Bobby Unser, the commentator on ABC, noted repeatedly after the various accidents during the race that but for the fact that they were using methanol alcohol—was the phrase he used—as the fuel, there would have been substantially greater injury and fires associated with the accidents that occurred in this year's race.

I should also note that Cal OSHA, the California occupational safety and health program which is more stringent than the Federal standards, has recently found that existing recommended practices for the handling and use of gasoline should also adequately protect individuals—translate that to be employees and service stations—when using methanol fuel.

And finally, certainly from an inhalation perspective, methanol poses a lower health hazard than gasoline since it will contain little or no benzene. And, of course, the benzene evaporative emissions alone are what justify the so-called Proposition 65 warning at all service stations in California today.

One other point I would note for you is finally in passing we have tried to evaluate what the implications would be of a spill of methanol similar to that which occurred with respect to crude oil in Prince William Sound. And our preliminary conclusions are that because of the solubility of methanol, the adverse impact would have been minimal compared to the effects which are now occurring vis-a-vis the crude oil spill. Methanol is found naturally in the environment and it is biodegradable in aquatic habitats, completely soluble in water, and because of that, it would have been completely dispersed within a one day time period. It would probably have had an impact on fish and wildlife in the immediate high concentration vicinity, but in dispersal, none of the problems associated with habitats along shorelines and in bays that we are trying to deal with in Alaska today.

Finally, let me note that the preliminary findings, which have not been completely adopted by the Governor's Advisory Board, have not identified any methanol related health and safety concerns that would preclude its use as a safe transportation fuel.

I wanted to comment—and I have extensive comments in my prepared written testimony which I would appreciate if you could include in your record—with respect to our views about the applications of other fuels. I would like to reiterate that we believe that there are, in fact, substantial and very important applications for ethanol, natural gas. I neglected to say propane, and I should have included that, and electricity as well.

We believe ethanol is very likely to be a very significant feedstock resource for oxygenated fuel programs in areas that do not have the kind of ozone problem that we have in California.

We believe that propane and CNG offer particularly good niche market applications in dedicated fleets.

And certainly electricity, particularly with increased research and development activities on the part of the Federal Government to enhance battery and engine development can, in fact, be one of the cleanest forms if it is using off-peak electricity for the fueling source, if you will, or the source for the charging of the batteries. And I would suggest that Federal vehicles, such as postal vehicles and so forth, would be absolutely ideal applications for all of the obvious reasons, limited driving needs during a given day and returned to central depots on a daily basis.

Let me just touch quickly on a few recommendations that we would offer to you.

First, I think it is important, as you indicated, that we recognize that the act of last year, while very important and critical to inducing the automobile manufacturers to proceed, needs a companion piece, if you will, with respect to encouragement for the petroleum and the fuel distribution industry. We have been working very assiduously in California to try to find that companion piece, and I would urge you to consider the concepts that we have tried to enunciate, such as fuel pool averaging, that have the benefit of potentially providing an economic incentive for petroleum companies to pursue investment in new methanol and other alternate fuel strategies while at the same time allowing them to pursue a broad and flexible response to increased standards for fuel content, including the prospect of dramatically improving the quality of gasoline as we know it today undoubtedly through the substantial reduction of aromatic contents, et cetera.

We should also urge full funding for the Rockefeller-Sharp legislation of last year. We believe the $18 million as a complement to California's efforts is a very modest effort on the part of the Federal Government to actually assist in the final demonstrations of these vehicles before we go to retail test marketing.

We would urge that all of your programs be fully integrated with the Nation's air policy, and that certainly seems to be the direction of the administration's proposals as well as those which have been introduced in both houses of Congress, the Waxman-Lewis bipartisan bill in the House and I believe Senator Wirth's bill here in the Senate.

We should urge you to consider that all federally subsidized vehicle acquisition programs for state and local governments should be low emission vehicles using clean fuels, and that not only includes UMTA, but also Federal support for a broad range of other fleets, not the least of which are Federal fleets themselves. We think what UMTA is doing is correct, but those principles ought to be more broadly extended throughout the Federal Government.

We do think, however, in enunciating goals in terms of vehicles, such as those in the legislation, it is important to work very closely with vehicle manufacturers to determine realistic goals. We have not been reticent to criticize targets that we believe are overly ambitious. At the same time, obviously, targets must be defined that provide sufficient incentive to move forward in an aggressive fashion.

I am not going to offer suggestions today about specific numbers, but I must say to you that we have found the automobile industry in this regard to be quite cooperative in recent years, and I think that you should encourage that kind of response because the partnership approach in our judgment is the only way to achieve the results that I think we all desire.

We do think that there should be additional Federal effort in terms——

Senator ROCKEFELLER. Chuck, could you hold for 30 seconds while I step outside for a phone call?

Mr. IMBRECHT. Certainly.

Senator ROCKEFELLER. Just a 30 second recess.

[Recess.]

Mr. IMBRECHT. The South Coast Air Quality Maintenance District adopted a rule recently that requires that at the time of the replacement of one or more tanks at service stations, that at least one installation be methanol or ethanol compatible. We would urge consideration of that kind of provision in future legislation because it is a very cost effective strategy to begin building the necessary infrastructure in areas where these kinds of approaches will be necessary.

As I indicated, we think that the Federal Government can assist greatly in terms of additional research and development. We believe that the demonstration activities with respect to methanol are well advanced, but research and development in terms of electric vehicle technology, optimized methanol engines, quicker refueling capabilities for compressed natural gas, et cetera, would all be appropriate activities for the research and development activities of the Federal Government.

Finally, let me indicate that the Carnegie Mellon study of emissions in southern California is clearly the most comprehensive air modeling that has been done anywhere in the United States. It is the result of a very prodigious collection of data, many sensing sites over a long period of time, et cetera.

We would suggest that a similar effort is necessary in other nonattainment areas throughout the United States to be able to adequately assess in an analytically acceptable fashion the benefits and detriments as they may exist with respect to any of the strategies. And we think in that context the Federal Government is in a particularly ideal position to sponsor air shed modeling studies to help us better understand how to meet our standards.

Let me simply conclude by saying that we have seen a great deal of progress in the last year and a half or two since I first had an opportunity to begin to work with you. We are adding additional major oil companies very shortly that will be participating on a voluntary basis in terms of marketing M85 or methanol in California. We have executed agreements with General Motors and very shortly we expect with Ford for the delivery of our final more than 5,000-car test fleet. We are proceeding with the acquisition of approximately 1,000 new high technology school buses in California, at least one-third of which will be clean fuel and the other two-thirds of which will be designed to optimize conventional diesel technology. We have also initiated our heavy duty truck demonstration programs ranging from dump trucks to tractor-trailer hauling rigs. And in all of those instances we look forward to working in a continued cooperative fashion with the Federal Government.

We again commend you for your leadership as well as the other Members of the Senate and hope that we will soon see the day where we, in fact, have a diversified transportation fuel mix, one which, as I said earlier, protects our national energy security as well as improving the quality of the air we breathe.

Thank you very much.

[The prepared statement of Mr. Imbrecht follows:]

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Testimony of
Charles R. Imbrecht, Chairman
California Energy Commission
before the
United States Senate
Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development
Washington, D. C.
June 8, 1989

I. Introduction

Mr. Chairman and members of the Committee, thank you for inviting me to this hearing to testify on the use of alternative motor vehicle fuels. I want to acknowledge and compliment the Committee on their efforts to help resolve the nation's energy problems and for recognizing the role that clean alternative fuels can play.

For many years, the California Energy Commission (Energy Commission) has promoted the use of cleaner fuels and low-emission vehicles to improve air quality and diversify transportation energy sources. This work began with the primary intent to reduce our dependency on petroleum and insulate our state from fuel price shocks and supply disruptions. However, based on the results of this activity, the Energy Commission finds that cleaner alternative fuels provide a remarkable opportunity to overcome what seemed to be insurmountable air quality problems. Our efforts are now expanding, and we are finding new support from all sectors of industry and government.

California is the third largest consumer of gasoline in the world. The state uses an average of more than one billion gallons per month, and its transportation system is 99 percent dependent on petroleum-based fuels. This dependence consumes 74 percent of the state's annual petroleum supply. Crude oil imports are expected to represent 50 percent of the nation's oil demand by the mid-1990s which increases the potential adverse impact if supply is suddenly reduced.

Even with the nation's most aggressive program to combat air pollution, California's major urban areas still do not meet federal air quality standards. In the Los Angeles area, the nation's highest unhealthful levels of ozone persist for most of each summer. In 1988 in this area, the federal ozone standard was violated 176 days, and on the worst day peak ozone was three times the allowable level. Every other major urban area in California also experiences exceedances of the federal and state ozone standards. Recently, a staff report of the California Air Resources Board listed 25 candidate or previously identified toxic substances which are known or suspected emissions from gasoline and diesel motor vehicles. As lead was phased out of gasoline for obvious health reasons, other hydrocarbons such as benzene were added to regain lost octane. This report estimates that benzene in gasoline and diesel particulate emissions now account for over 60 percent of the cancer risk associated with motor vehicle use in California.

With post-combustion pollution controls reaching a level of diminishing returns, it is clear that cleaner alternative fuels must be used to help improve California's energy security and reach the state's air quality goals. Moreover, with an ever growing realization that global warming due to greenhouse gases is a serious environmental concern and that transportation sources are major contributors to the inventory of these gases, the Energy Commission finds that the potential benefits from its clean alternative fuels program to be even greater than previously believed. The cleaner transportation fuels being pursued by the Commission--methanol, ethanol, natural gas, propane, and electricity--can all fit into an integrated strategy to reduce current levels of important greenhouse gases, carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). The cleaner fuel choices made for air quality or energy diversification reasons do not involve any compromise with strategies to reduce global warming. Their use, in fact, would have a smaller greenhouse impact than continued use of gasoline.

Although the Energy Commission's activities in clean alternative fuels for transportation continue to emphasize methanol fuels, the Commission recognizes that a mix of clean fuel options gives consumers the benefit of selecting fuels and technologies that can best satisfy their service needs and create beneficial competition. For widespread market acceptance, the Commission and many other authorities believe that methanol fuel offers the simplest, cost-effective option to petroleum fuels because 1) it is a clean burning liquid alternative that can substitute for both gasoline and diesel , 2) it is the least disruptive alternative for consumers, automotive companies and the fuel distribution industry, and 3) it provides equal or superior overall vehicle performance. However, methanol is not a panacea, and other cleaner fuel options will continue to be evaluated and demonstrated by the Energy Commission for applications that present clear market potential and benefits. Thus, the focus of this testimony will be on the Commission's work relating to methanol fuel but it will also attempt to highlight points regarding other cleaner fuels.

II. Background of California's Alternative Fuels Program

The Energy Commission's alternative fuels program started in 1978 with field evaluation of relatively small volumes of alcohol fuels blended with gasoline. Demonstrations concentrated on alcohol fuel use in light duty passenger vehicles. Both ethanol and methanol fuel technologies were demonstrated.

In brief, these programs showed that methanol was the most practical of the alcohol fuels for widespread use in California. Production studies revealed that ethanol was much more expensive to produce and sell commercially in California as compared to other sources, and without continued financial incentives such as reduced state and federal excise taxes, it appeared uneconomic. Conversely, methanol costs significantly less than ethanol to produce and could come from a variety of resources. Therefore, since the early 1980s the Energy Commission's alcohol fuel program has concentrated on methanol.

Demonstrations have been conducted using M85 or M90 (85 or 90 percent methanol with 15 or 10 percent gasoline, respectively) in retrofitted and original equipment manufactured automobiles dedicated to methanol fuel. In 1983, more than 500 factory-produced methanol Ford Escorts were placed in fleets throughout California. This fleet has accumulated nearly 22 million miles, with most vehicles still in service. In the same period, a methanol refueling network was established in a limited number of independent service stations throughout California to provide service for these fleets.

Although this fleet experience has been a technical success, the limited fuel access and single-fuel nature of the Escorts significantly reduced their driver acceptance; a new technology, however, is now poised to overcome these problems. For the past two years, the Energy Commission has demonstrated several first generation fuel flexible vehicles (FFV) manufactured by Ford Motor Company and General Motors Corporation. FFVs are capable of operating on alcohol fuels, gasoline, or any blend of the two. Thus, the fear of running out of fuel or having a restricted driving range should no longer be factors in methanol vehicle operation.

The Energy Commission also began in 1983 a demonstration of heavy-duty methanol fueled transit buses at Golden Gate Transit District in San Francisco. Through a grant from the Urban Mass Transportation Administration, the Commission continues to operate these methanol fueled buses in revenue service to determine their long-term durability characteristics. Public surveys and questionnaires collected from individuals who ride in these vehicles show a distinct and favorable impression in contrast to the public's normal reaction to transit buses. Emissions testing on these buses has indicated that methanol fueled heavy-duty vehicles have significantly lower emissions than their diesel counterparts.

A second California methanol bus demonstration was started in 1988 at Riverside Transit Agency. Sponsored by the Air Board and the Energy Commission, this program examines the potential of retrofit technology to convert many existing diesel fueled buses to methanol fuel. Successful completion of this activity will open the way for many other transit operators to gradually begin using methanol, converting over when normal engine overhauls are performed.

The Energy Commission is currently implementing a large Fuel Flexible Vehicle Demonstration with the goal of operating 5,000 FFVs in California by 1992. An agreement between the Energy Commission and General Motors will result in 2,220 of these vehicles by June 1992. A similar agreement is being consummated with Ford. These vehicles will be purchased by private and government fleets throughout the state and are considered the current state-of-the-art in alcohol cars.

The Energy Commission has long recognized that vehicle demonstrations alone do not create a self-sustaining market for alternative fuels. Building a supply and distribution infrastructure for these fuels must also be linked to the demonstration activity. Thus, the Energy Commission has sought the active participation of existing energy companies to achieve a transition balance, matching fuel demand with supply. Much to their own initiative, ARCO and Chevron have entered into cost sharing agreements with the Energy Commission to place methanol fueling facilities at public fueling stations across the state. Up to 50 methanol fueling facilities will be operational by the end of 1991. The Commission is now also discussing similar partnerships with three other major energy companies.

The Energy Commission has recently initiated a demonstration of methanol in heavy-duty trucks. The work involves a number of engine technology concepts with government and private fleets throughout California. These fleets are also contributing their own resources in conducting the demonstration. This activity is supported by major engine manufacturers--Caterpillar, Cummins, Ford, Detroit Diesel, and Navistar. Some of these engines will use methanol with Avocet, a fuel additive manufactured by ICI Americas, Inc.

In a cooperative effort with the Air Resources Board (Air Board), South Coast Air Quality Management District (South Coast District), and the Southern California Rapid Transit District (SCRTD), the Energy Commission has agreed to support the establishment and operation of a heavy-duty emission test facility at SCRTD in Los Angeles. The facility is a major component of the SCRTD demonstration of 30 newly built and 12 retrofitted methanol buses. This state-of-the-art facility will be capable of performing engine and chassis, steady-state and transient emission tests. Scheduled to begin operation in 1990, the facility will enable the agencies to obtain detailed emission data from both diesel and alternative fueled heavy-duty vehicles from all existing and planned demonstrations in California.

In addition SCRTD is participating in a program with the Southern California Gas Company (SoCal Gas) to demonstrate CNG in two of their buses using a Cummins L-10 engine. SCRTD is also ordering Cummins methanol powered buses for 1990. Orange County Transit (OCT) is planning a demonstration with six clean fuel buses--two with methanol, two with CNG, and two with propane. OCT is expecting to begin this work later this year.

The state's largest demonstration of clean fueled heavy-duty engines will begin in 1990 with 50 methanol school buses and 100 cleaner diesel buses (Phase I). This originates from recent California legislation which created a $100 million program using Petroleum Violation Escrow Account (PVEA) funds for the Energy Efficient School Bus Demonstration Program. Non-petroleum based alternative fuels, as well as energy efficient advanced diesel technology, will be demonstrated as part of an integrated strategy with the potential for simultaneously reducing California's dependence on foreign oil and reducing emissions of major air pollutants. The demonstration has a goal of purchasing at least 1,000 low-emission buses. The 1990 Phase I demonstration will be followed with a planned 1991 purchase of some 600 vehicles with more than 200 being clean fueled and the remainder using advanced cleaner diesel technology. Finally, Phase III will generate another 250 vehicles.

III. Current Status of Methanol

A. Methanol Supply and Cost

Today's worldwide methanol production capacity consists of about 75 plants in over 30 countries, currently capable of producing between six and seven billion gallons per year. Given conventional chemical market demands for methanol, the existing supply system can be counted on to make only a limited contribution to fuel supply. Nevertheless, this can be sufficient to annually provide methanol fuel for a million automobiles, enough to initiate the most optimistic methanol transition scenario. For future demand, the physical potential for expanded production capacity is considered to be substantial, including many opportunities for using natural gas resources in places remote from pipelines and economic markets. Further growth in methanol demand for fuel markets, added to any growth in traditional chemical markets, will accelerate the need for expanded worldwide production capacity.

The Energy Commission is aware of the considerable natural gas resources that are located in the Middle East and the related concern of possibly falling into another market situation that is controlled by foreign nations. However, the Commission finds that the diversity of worldwide supply options for methanol makes it less susceptible to market control by a single production entity. Also because of emerging methanol fuel flexible vehicle technology, consumers will have the ability to switch between methanol, ethanol and gasoline depending on fuel cost, availability or performance preference. This also reduces the influence that might be exerted by any OPEC-like cartel formed to restrict a methanol market. The U.S. Department of Energy in its report, Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector, makes similar conclusions, and suggests that "any increase in the total potential supply of liquid fuels... should tend to enhance U.S. energy security, because it would cause the world energy market to loosen up."

Methanol also has the potential of being produced from coal resources as other feedstock costs increase over time. However, dedicated coal-to-methanol facilities would emit greater amounts of CO_2 than other options, leading to an increased global warming effect. Thus, this option appears viable only if cost-effective techniques are developed to remove excess carbon or CO_2 emissions from coal conversion technologies or through advanced conversion technologies.

For example, one advanced technology called methanol co-production combines coal gasification, electricity generation, and methanol production in a single facility. Analysis indicates that the use of coal in such a facility results in a net reduction of CO_2 when compared to an equivalent dedicated power plant burning coal and using an amount of gasoline equal in energy to the co-produced methanol. Brookhaven National Laboratory is also investigating a very promising technology to remove excess elemental carbon from coal. If successful, this process would automatically allow for the precise control of CO_2

produced during coal combustion. The federal government's Clean Coal Program should consider supporting research and development of these technologies, making coal a more acceptable feedstock for fuel production.

Pending successful demonstrations of full scale methanol co-production or the Brookhaven concept, the Energy Commission's analysis indicates that from an economic perspective, coal would not be a major source of methanol until well into the next century. Extensive resource evaluations conducted by the Energy Commission and the U.S. Department of Energy continue to show that near- and mid-term methanol supply, possibly even for the next 50 years, will primarily be produced from plentiful remote natural gas resources.

The output of a typical new methanol plant, around 200 to 300 million gallons per year, could serve about one percent of California's gasoline market. A complex of four large-scale plants at a single location, however, could have a combined output of over one billion gallons per year, enough to serve five percent of California's gasoline demand. At the projected demand level, it does not appear that methanol supply will be a limiting factor to methanol use in the transportation sector.

A joint California government and industry study, the California Fuel Methanol Cost Study, projects the capital costs of a new methanol plant in various locations in the world. The study's results coupled with reasonable financing assumptions suggest that methanol could be delivered to Los Angeles at a cost competitive with gasoline produced from petroleum. This analysis supports the Energy Commission's belief that methanol can provide for a cost-effective and long-term clean air strategy.

The above cost analysis is also consistent with the Commission's market penetration scenario for methanol fuel as a direct competitor to premium gasoline. With a cost projection equivalent to high octane gasoline, and yet offering an octane rating that is ten points higher (102 versus 92), methanol M85 fuel could easily become the consumer's choice from a performance standpoint. The increased performance is even distinctly apparent in fuel flexible vehicles, let alone in optimized engines.

B. Methanol's Air Quality Benefit

Although some are still suggesting that the air quality benefits of methanol are overestimated or uncertain, testimony provided to the Air Board, the South Coast District and the Governor's Board on Air Quality and Fuels, indicates that widespread use of methanol fuel will have a significantly positive impact. A recent air quality study sponsored by the Air Board and the South Coast District and performed by Carnegie Mellon University investigated methanol use in the South Coast Air Basin. This study indicated that significant reductions in ozone attributable to motor vehicles would likely be achievable with wide scale adoption of methanol as a fuel.

Based on results in the study, the Energy Commission calculates that mobile source peak ozone levels could be reduced in the basin from between 29 (pessimistic M85 case) to 69 percent (optimistic M100 case). With the latest data from emission tests from California's fuel flexible vehicles, the likely peak ozone reduction level would be at least 50 percent. The ozone benefits will be retained even in multi-day episodes which are frequently experienced in the Los Angeles area. Furthermore, the authors of the study conclude that there will be simultaneous benefits in vehicle emission reductions of particulate matter (PM10) and oxides of nitrogen (NO_2), as well as lower atmospheric concentrations of benzene, peroxyacetyl nitrate (also known as PAN, an eye irritant and plant toxin), and nitric acid (acid rain constituent).

The benzene reduction is particularly important since this compound is a known human carcinogen and is appropriately designated a toxic air contaminant by both the federal government and California. As mentioned earlier, a recent Air Board staff report estimates that benzene emissions and diesel particulate matter alone are responsible for over 60 percent of the cancer risk associated with motor vehicle emissions in California.

The Carnegie Mellon University study also examined the issue of formaldehyde emissions from methanol vehicles and the impact that these emissions would have on atmospheric formaldehyde concentrations. In scenarios that assumed that methanol vehicles in the future will achieve the recently adopted California standards for formaldehyde, effective in 1993, summertime formaldehyde exposures will be reduced in the range of 13 to 17 percent. The authors point out that this decrease occurs as a result of the displacement of gasoline and diesel emissions which, if present, would have been transformed into formaldehyde in the atmosphere. While California's current methanol demonstration vehicles do not yet meet the 1993 standard, considerable improvement over early generation vehicle performance has already been achieved; this leads us to strongly believe that catalysts specifically designed and optimized to control formaldehyde will soon be available. Consistent with this optimism, the Environmental Protection Agency has just reported that advanced technology catalyst designs have formaldehyde emission rates which are about one-third of the allowable 1993 standard.

C. Methanol Health and Safety Characteristics

In some respects, methanol in comparison with gasoline is a safer fuel. The relative risks of fires originating from leaks or spills of methanol, gasoline and diesel were discussed in detail at the Methanol Health and Safety Workshop conducted by the South Coast District on November 1-2, 1988. In an open spill, methanol is less flammable and requires a higher ignition temperature than gasoline. If a fire occurs, a methanol fire can be extinguished by sufficient water dilution whereas gasoline will float on top and continue to burn. Perhaps more importantly, the temperature and intensity of a methanol fire is much lower than a comparable gasoline fire because of methanol's inherently lower energy content. Its fire safety advantages along with its performance characteristics has made methanol the preferred fuel over gasoline at the Indianapolis 500. Although pure methanol burns with a near invisible flame and has no obvious fuel odor, these safety disadvantages are eliminated when a small amount of gasoline, e.g., 15 percent, is added to methanol. Nevertheless, fire safety officials should become more knowledgeable about methanol's fire characteristics and insure proper training for fire fighters and the correct labeling of storage systems.

The Consultation Service of California's Division of Occupational Safety and Health finds that existing recommended practices for the handling and use of gasoline should also adequately protect individuals when using methanol fuel. These practices were originally adopted by the petroleum industry for gasoline. Because the exposure risk to the average consumer using methanol fuel will be no greater than for one who works in the fuel industry, methanol should not represent any greater safety risk than gasoline. Certainly, from an inhalation perspective, methanol poses a lower health hazard than gasoline since it will contain little or no benzene. However, if the siphoning of methanol from automobile fuel tanks were to occur frequently, there is a potential for more frequent adverse health impacts. The Air Board in California has addressed this potential by adopting a general provision in its 1993 methanol vehicle standard which requires the installation of an anti-siphoning device. Since the swallowing of gasoline can also be extremely dangerous and potentially fatal, the Energy Commission recommends the federal government consider a national requirement for an anti-siphoning device for all vehicles.

The recent oil spill in Alaska's Prince William Sound has refocused our attention on the environmental hazard of petroleum distribution. A preliminary analysis by Energy Commission staff suggests that had a similar spill occurred with methanol, the adverse impact would have been minimal compared to the effects now occurring. Methanol is found naturally in the environment and is biodegradable in aquatic habitats and completely soluble in water. Its solubility would have allowed a similar Alaskan spill to be completely dispersed within one day. Laboratory research in California and Japan on the transport and effects of methanol spills in the marine environment shows rapid dilutions to concentrations that are not acutely hazardous to typical marine life. In addition, the New Energy Development Organization of Japan reports that fish can sense an increasing concentration of methanol and will swim away out of harm. With methanol, marine life would not become coated with a life threatening film as with oil.

As in the case of gasoline and diesel fuel, methanol leakages from underground tanks or spills on land have the potential of contaminating groundwater. Generally however, methanol that enters the groundwater system appears to present a much smaller environmental problem than petroleum fuels. Methanol dissolves quickly in water to low, non-toxic concentrations, and it is eliminated much more rapidly than gasoline or diesel by natural bacteria and oxygen. Note that methanol is actually used to enhance biological life employed in the normal operation of human sewage treatment facilities.

In California where all underground storage systems for hazardous materials are now required to have either double-wall containment systems or leak detection monitoring devices, or both, the contamination potential of any inadvertent release of fuel is extremely remote. To plan for even these unlikely events, California will initiate research projects to more fully evaluate methanol's behavior in groundwater sources found in various geologic strata. Other work will also evaluate methanol leak detection and monitoring methods, spill remediation and clean-up techniques. Preliminary information indicates that methanol leakage will be easy to detect, and that any potential leak can be reduced to negligible levels with relatively simple equipment. It is likely that methanol leakages would be easier to manage than petroleum fuel contamination of groundwater. In none of the proceedings conducted to date in California has it been determined that underground leaks of methanol would be a certain health concern. However, health and safety officials should investigate further to accurately predict the results of such fuel leaks.

The California Legislature and the Governor have appointed a joint government and industry panel, the Advisory Board on Air Quality and Fuels (Advisory Board), to identify and propose further incentives and/or mandates for the state to improve air quality through low-emission vehicles. As a part of this task, the Advisory Board conducted a fact-finding workshop, the Environmental, Health and Safety Workshop, on November 29-30 and December 1, 1989. The topics discussed at the workshop include fire and explosion risks, the impacts of spills and leaks, and the ingestion, absorption, and inhalation consequences of alternative fuels relative to petroleum products. Based on the information received at the workshop, proposed findings have been presented for the Board's eventual adoption. These proposed findings have not identified any methanol related health and safety concern that would preclude its use as a safe transportation fuel.

IV. Current Status of Ethanol

Over 150 ethanol production facilities currently exist in the United States, with a total capacity of over one billion gallons per year. Most of these production facilities are concentrated in the Midwest grain-producing states. California has three operating ethanol plants with a combined capacity of about eight million gallons per year, using mostly waste-product feedstocks from the dairy and beverage industries. Most of the ethanol produced in the United States is used for gasohol, amounting to nearly one percent of the United States' gasoline being displaced with ethanol. California also uses ethanol for gasoline blending purposes. Current ethanol demand for blending is about 50 million gallons per year, most of which comes from the Midwest via rail car.

Due to the current federal subsidy, equivalent to 60 cents per gallon, ethanol has been and will likely continue to be economically competitive as a gasoline blending agent, especially when gasoline prices are high. The economics are further enhanced by individual states that offer additional fuel excise or sales tax reductions. However, California air quality agencies have expressed concern regarding the higher evaporative emissions that come from gasohol and suggest that all automotive fuels be produced at or below the same Reid Vapor Pressure standard; gasohol is currently exempted from this standard. Without the federal subsidy, ethanol is likely to cost over twice as much as gasoline by the year 2000, and for this reason, it will likely be used as a feedstock for oxygenated fuels and not as a neat fuel.

V. Current Status of Natural Gas

In contrast to petroleum, natural gas is comparatively inexpensive and plentiful in North America. Fields in the southwestern United States, as well as California and the Rocky Mountain region, constitute much of the indigenous supply. Despite adequate supplies of natural gas, it is the gas pipeline transportation system that presents the greatest difficulty in assessing resource potential. If significant new demand for natural gas is to develop, it is the pipeline transportation system that will require additional capacity. Because of its clean burning characteristics and relative cost, natural gas is increasingly being viewed as the fuel of choice for stationary power generation. It may well be that this application will have priority over its potential use in transportation markets.

Vehicles using natural gas as a fuel have been available since the early 1920s and currently number about 30,000 in the United States. Most natural gas vehicles are operated as dual fuel vehicles. Technological limitations on refueling and vehicle range have tended to keep the popularity of natural gas as a vehicular fuel fairly low. The expense of purchasing compressor systems and the associated period required to recoup those costs through fuel savings appear to make natural gas an option for fleets with central fueling facilities.

Current applications within California of natural gas vehicle operations include a postal service fleet of 100 vehicles comprised of American Motors Jeeps and Dodge pickup trucks. Two California gas utilities have had demonstration fleets of 1/2 ton pickup trucks that were discontinued due to low gasoline prices and other corporate factors.

The Energy Commission will shortly begin a compressed natural gas (CNG) demonstration in heavy-duty engines to more fully explore its economic and performance potential as a transportation fuel and its ability to meet California emission standards.

VI. Current Status of Liquified Petroleum Gas

In the United States, about 70 percent of the liquified petroleum gas (propane) is extracted from natural gas, while 30 percent is refined from crude oil. Nationally, the United States supplies approximately 85 percent of its domestic demand, with the additional 15 percent of demand being met with imports. On the West Coast, the supply of liquified petroleum gas comes from refining operations (about 50 percent), interregional transfers, offshore gas production on the Outer-Continental Shelf, and imports. Future California liquified petroleum gas demand is projected to decrease from current levels, resulting in potential surpluses.

There are several propane fleets and individual applications currently in operation in California. The number of propane vehicles in the state is estimated to be about 80,000. Nationally there are about 370,000 vehicles, and millions operate worldwide. At this time, propane appears to offer lower fuel costs to large fuel users located near ample supplies.

VII. Status of Electric Vehicles and Hydrogen Fuel

The Energy Commission is increasing its interest in other forms of transportation energy that have the potential to contribute to air quality improvements in the longer term. The growing alarm over the global warming problem, added to our existing urban air pollution problems, drives us toward implementing the cleanest possible transportation technologies for the future. This includes applications of energy that can virtually eliminate mobile emissions of carbon compounds. The Energy Commission is looking at three technologies that may achieve this: electric propulsion using storage batteries, hydrogen-fueled internal combustion engines, and fuel cells (producing electricity on-board for electric propulsion).

Battery-powered electric vehicles (EVs) may soon begin to have limited application in commercial fleet operations. Both General Motors and Chrysler are supporting the production of electric van models, prototypes of which illustrate the recent progress in EV technology. Ford Motor Company is also investigating an electric van application. Within the next few years, these vans will be in use in a number of California fleets, especially those of the electric utilities. In this time frame, it is expected that new generations of battery technology should appear biennially, giving EVs increased performance and range with each generation.

To coordinate EV programs in the state, the Energy Commission and other public and private organizations formed the California Electric Vehicle Task Force. The Task Force was organized in 1988 to advance the development and introduction of EV technologies. The Energy Commission is placing emphasis on selected RD&D efforts that can expand the potential use of EVs in the state. One example is the recent support provided by the Energy Commission to the Electric Auto Association for a project, in conjunction with Stanford University, that will design and build a "hybrid" electric vehicle prototype. The hybrid concept employs a small internal combustion engine along with electric propulsion, to increase the vehicle's driving range and performance. This is one approach to making EV technology compatible with more types of vehicles and driving patterns, including private commuter vehicles.

Driving range, along with initial vehicle cost and battery life, appear to be the key development issues to resolve for wider EV application. Although there are additional unresolved and complex issues related to the generation and supply of electricity for a large transportation demand, a preliminary assessment of electricity supply implications of EVs suggests that the state's electricity supply system could comfortably accommodate the off-peak charging requirements for a considerable introduction of EVs.

The use of hydrogen as a transportation fuel, as well as on-board vehicle fuel cells, are technologies with longer development timetables and less concerted RD&D efforts in the U.S. However, the Energy Commission continues to monitor progress with these technologies and to consider what type of role in their development may be appropriate for California. Rapid progress in both technologies is expected with improved molten carbonate fuel cells and better fuel storage systems for hydrogen.

VIII. Federal Government's Potential Role in Alternative Fuels

A. Purpose and Approach

California has aggressively adopted a clean fuels strategy, not as a panacea, but as a key component of a broad program to reach attainment of ambient air quality standards and diversify the state's mix of energy resources. Based on our experience with several large scale demonstration programs, a single state's clean fuel strategy would take considerably longer to implement and have greater difficulty in achieving lasting results than one which is adopted as a part of a national effort. Clearly, the expansion of California's clean fuel efforts will require the support and assistance of the federal government. The need for energy security and air quality improvements in this country requires that government continue to encourage the use of clean alternative transportation fuels on a broader spectrum.

To achieve greater market penetration of clean fuels, the California Energy Commission has stressed close working relationships with the private sector. We have been successfully operating both light- and heavy-duty methanol fueled vehicles through demonstration programs in cooperation with original equipment manufacturers, the methanol industry, and more recently major energy companies. These programs show that methanol could substantially improve the state's air quality and provide equivalent, if not superior, service as a transportation fuel.

In general the state has achieved private sector involvement in our demonstration programs through incentives rather than mandates. These incentives include demonstration funds for cost-sharing the purchase of test vehicles and co-funding of methanol fueling stations at major retail outlets. Although state resources were allocated for these projects, the private sector contributed as much, if not more, funding for their participation. Incentives may also take the form of initiatives which create a "level playing field" for clean fuels, low-emission and high energy efficient technologies.

California has attempted to develop incentives tailored to internalize air quality benefits and allow markets to develop the technologies, rather than relying on long-term subsidies. This, however, has proven to be an extremely difficult goal given the desire to treat all economic groups fairly and in a non-regressive manner. Nevertheless, the federal government should consider this approach and examine the mechanisms available to make consumers more aware of the air quality costs and benefits when choosing fuels and vehicles.

A very significant federal legislative incentive was the passage and signing of the Sharp-Rockefeller Alternative Motor Fuels Act of 1988. This legislation provides a credit to automobile manufacturers in calculating their Corporate Average Fuel Economy (CAFE) for building methanol, ethanol and natural gas fueled vehicles. This credit will provide an incentive to produce fuel flexible vehicles to automobile manufacturers who have difficulty in meeting the CAFE standard. The Commission is convinced that this incentive will prove key to the success of California's cleaner fuel program.

One of the most effective actions that California has implemented, which is the basis and background for our program successes, is the integration of the alternative fuel program to California's clean air policy. The Energy Commission recommends that the federal government consider a similar integration of programs.

B. Vehicle Purchases

The Energy Commission encourages the federal government to expeditiously move forward with provisions of the Alternative Motor Fuels Act of 1988 which would more fully involve federal fleets in operating low-emission vehicles using clean fuels. This sends a positive economic signal to vehicle and fuel markets and reduces the perception of financial risk. We are currently discussing the purchase of fuel flexible vehicles with the federal government's General Services Administration in an effort to coordinate our activities with automotive manufacturers. A combined effort can help assure that we pay the lowest possible price for these vehicles through volume purchase, and it also indicates to methanol producers the potential of a fuel market.

One federal option to encourage the use of cleaner fuels in other parts of the country may be through the Urban Mass Transportation Administration (UMTA) bus purchase mechanism. UMTA currently provides 80 percent of the funding for new bus purchases, with local government providing the remaining 20 percent. Because of the impending 1991 heavy-duty engine emission standards, there appears to be a tendency to delay purchase of new transit buses. Rather than purchasing cleaner fueled buses which will meet the 1991 standard, many transit operators are considering to delay new bus purchases, hoping that the standard will be postponed, relaxed or that another solution, such as particulate traps, will be available at a later time. In lieu of the current formula the federal government might consider developing and using an optional funding formula which encourages purchase of cleaner fueled, low-emission vehicles.

In the proposed federal Clean Air Restoration Act of 1989, HR 2323, Section 186. (d), a provision exists to require that buses leased or purchased by a State or local government shall be low-emission vehicles using clean fuels. The Committee should consider this approach for all fleets supported with public funds in addition to the above suggested UMTA mechanism.

California has also enacted legislation in 1988 to allow a clean air surcharge on vehicle registration fees in the South Coast Air Basin and Sacramento County. The funds

generated from the surcharge will be earmarked for clean fuel programs in both locations. I have attached copies of the respective California codes which place these fees into law (Attachments A and B).
The state is currently exploring other methods of providing incentives for promoting cleaner fuels. The Energy Commission along with several California gas and electric utilities are supporting proposed state legislation which will provide a sales tax exemption on the incremental cost of a low-emission vehicle (Attachment C).

Although these incentives look promising, they may not be enough to achieve significant market penetration of low-emission vehicles. Other strategies, such as mandates, are already being implemented in California's South Coast Air Basin. This approach may be necessary for other severely impacted regions. The South Coast District is currently considering a regulation, Rule 1601, requiring fleet operators to purchase low-emission vehicles for their fleets. This will have the effect of introducing low-emission vehicles using clean fuels to those not familiar with their capabilities, exposing a greater population to their existence. In particular, rental car fleets are subject to the provisions of Rule 1601.

In the proposed federal Clean Air Restoration Act of 1989, HR 2323, Section 188. (d), a provision requires the establishment of minimum incremental percentages for new motor vehicle sales to be low-emission vehicles using clean fuels as a baseline for compliance strategies in extremely poor air quality areas. Such percentages should be carefully reviewed and that a realistic goal be set in consultation with vehicle manufacturers. Assessing the approximate numbers and types of vehicles that will be required to meet this demand and assuring that appropriate vehicles will be available are keys to the success of this strategy. We would be happy to cooperate and share with you the benefit of our existing working relationships with engine manufacturers who support California's program.

The Governor's Advisory Board on Air Quality and Fuels will publish a report in August 1989 identifying and proposing further incentives and/or mandates for the state to improve air quality through low-emission vehicles. It will offer recommendations to the Governor and the State Legislature regarding the best tactics for introducing low-emission vehicles utilizing cleaner fuels.

C. Fuel Supply and Distribution

Of concern to many policy makers in expanding the use of methanol fuel is its cost and supply, particularly during the early introduction period. To alleviate this concern, the Energy Commission has established the California Fuel Methanol Reserve (Methanol Reserve). The Methanol Reserve is a voluntary membership organization administered by the Energy Commission and comprised of methanol producers. The members of the Methanol Reserve must commit to supply a certain quantity of methanol over a period of time at a certain price. The price is determined by the Energy Commission through a calculation which estimates and includes an incremental monetary value for methanol's clean air benefit. The Energy Commission is responsible for allocating the Reserve's fuel supply to qualified methanol demonstration projects and insuring that each reserve member shares equally in supplying fuel.

The Methanol Reserve became operational in early 1989 with commitments from four major methanol producers--Hoechst Celanese, Ocelot Chemicals, Novacor Chemicals, and Celanese Canada. The Reserve currently has a volume commitment of nine million gallons at $.45 per gallon, which includes the cost of delivery and storage at terminals in Northern and Southern California.

The federal government should consider the potential of establishing a national fuel methanol reserve or implementing similar reserves in other areas of the country. The need for the Methanol Reserve in California is due to the low volumes of methanol that are currently used for fuel applications. The low volumes result in the use of high cost modes of distribution. This makes methanol fuel less economically attractive. However, large potential supplies of methanol can and are being produced in remote locations of the world at very low prices. These resources can be transported to the United States in large tanker ships if the demand is sufficiently high. The federal government is urged to maintain its current policy of allowing these sources of methanol for fuel applications to enter the country duty-free and develop additional mechanisms for increasing the fuel demand.

In the proposed federal Clean Air Restoration Act of 1989, HR 2323, Section 187. (e), a provision exists to require that once a compliance strategy has been approved in severe air quality areas, each tank installed for the storage of liquid fuels shall be capable of storing methanol fuel.

Beginning in 1988, the South Coast District began implementing a methanol compatible tank rule which takes advantage of the state's ongoing activity to monitor and replace worn and unsafe underground storage tanks. The rule requires that if one or more tanks are replaced at a site, at least one storage tank and piping system are to be methanol compatible. This is a cost effective strategy to begin building the necessary infrastructure for methanol distribution.

Additional market penetration analysis will help guide the use of initiatives in the most appropriate manner for the various cleaner fuels. An important strategy that is being discussed in California is how to introduce cleaner fuels such as methanol, ethanol, natural gas, and electricity as well as cleaner gasoline and diesel. In conjunction with regulatory activities under consideration by the Air Board, a group of oil companies and the Energy Commission are discussing with them a flexible standard that would give the fuel industry a variety of options to improve air quality by introducing cleaner fuels, including a cleaner gasoline, provided that these meet California's stringent air quality and fuel standards.

These discussions involve the concept of a standard based on a "fuel pool average" for each fuel marketer. This promising concept for additional air quality improvement is to place a cap on certain undesirable emission compounds (e.g., benzene, aromatics, and carbon dioxide) across all fuels sold in the state for each fuel marketer. Sales of methanol, CNG, and/or oxygenates for gasoline blends would lower a marketer's "fuel pool average" of these compounds. Currently formulated gasoline would exceed the caps. If marketers wish to continue to sell such gasoline, they would have to offer offset quantities of cleaner fuels. As another option for meeting their limits, companies could elect to operate fleets of cleaner fueled, low-emission vehicles.

This concept would give marketers flexibility in achieving their limits, but it would simultaneously provide incentives for them to increase sales of clean alternative fuels and/or low-emission vehicles to avoid penalties for exceeding the caps. California is pursuing a more thorough assessment of such a program to determine an optimum method for its implementation. Once California finalizes this analysis, we recommend consideration of a similar federal program for fuel pool averaging.

D. Technology Research and Demonstrations

Although the Energy Commission continues to support a variety of low-emission vehicle demonstration activities, it is clear that a national effort is important to show the economic potential to the private sector for developing new cleaner fuel technologies. This is particularly true for technologies that require significant research and development such as electric vehicles and battery technology and optimized methanol engines. We would also recommend a thorough evaluation of the feasibility for the emission reduction potential and cost associated with the concept of both cleaner gasoline and diesel fuels. Additional demonstrations of cleaner fuel technologies are essential for determining their full air quality benefits plus likely costs. Such demonstrations must also take place in coordination with increasing fuel availability.

Federal activity that could accelerate the creation of a successful fuel pool concept would be to extend research to all fuels containing oxygen components that could be used in refineries to formulate finished gasolines. Such components could help remove benzene and other aromatics. Additional assistance in evaluating candidate oxygenated gasolines in terms of vehicle performance, emissions and fuel economy could also remove important market barriers.

The potential for competing markets for the various feedstock resources should be further assessed to ensure the likelihood of adequate future supplies of alternative transportation fuels. For future significant levels of alternative fuel demand, fuel prices and their relationship to petroleum and competing market pricing need to be further evaluated.

Certification programs for emission control systems should be developed and implemented for those vehicles that are converted to alternative fuel capability, such as for compressed natural gas and liquified petroleum gas. All cleaner fueled low-emission vehicles require rigorous testing and development before they can be certified as low-emission. Qualification of low-emission vehicles may be more complex than originally anticipated. For your reference, a publication recently published by the Air Board addresses this topic. A copy of this report, "Definition of a Low-Emission Motor Vehicle in Compliance with the Mandates of Health and Safety Code Section 39037.05 (Assembly Bill 234, Leonard, 1987)" can be obtained directly from the Air Board. This report emphasizes that it takes a carefully engineered combination of clean fuels and engine technology to qualify a car as a low-emission vehicle.

In the area of vehicle emissions research, the Energy Commission recommends that the federal government support activities to evaluate and verify chemical mechanisms for use in photochemical models. For example, the work performed by the Air Board, the South Coast District and the Energy Commission revealed the hydrocarbon advantage of methanol vehicle emissions in retarding the atmospheric formation of ozone. Improved understanding of atmospheric chemistry and analytic models will allow for realistic comparisons of air quality benefits from all fuels. Work in this area should also be extended to explore the effectiveness of clean fuels to reduce known or suspected toxic emissions from motor vehicles by specifically requiring the measurement of toxic and unregulated emission species in emerging technologies.

The clean air benefit of methanol's hydrocarbon advantage over gasoline was discovered because of the detailed knowledge of emission inventories and air quality characteristics of the South Coast Air Basin. Without this immense data base, the impact of cleaner fuel substitution could not be predicted. The federal government is urged to implement a national program to collect such information and then to sponsor airshed modeling studies wherever plans are being developed to help meet clean air standards.

Lastly, perhaps through cooperation with the Environmental Protection Agency, the Energy Commission would be interested in co-sponsoring development of high efficiency, low-emission engines using cleaner fuels.

XIV. Conclusion

I welcome the opportunity to assist the Committee in exploring mechanisms for enhancing the potential for cleaner fuels and low-emission vehicles. The need for energy security and air quality improvements in this country requires that government actively encourage the use of cleaner transportation fuels. California applauds the achievements of the 101th Congress and the President to support this philosophy through the passage and enactment of

Public Law 100-494, the Alternative Motor Fuels Act of 1988. The Energy Commission supports continued efforts, through hearings such as this, to explore further ways to expand the use of cleaner motor vehicle fuels.

Senator ROCKEFELLER. Thank you very much, Chuck.

I would say to all witnesses that their full statements will be included in the record. I would say also to all witnesses that because they will be included that you should not feel the need to give the full statement. Condensing them is desirable. We are not in a hurry here. We will stay here as long as we need to be, and I want this to be a leisurely and full hearing.

I agree with you very much, Chuck, on what you said about CNG and electricity and ethanol. We have to look to all sources of alternative fuels. There is no doubt about that.

I also want to pay particular honor to what you, frankly, in your particular leadership has done in southern California. I think there would be a lot less interest, a lot less sense of impending possibilities if it were not for what you have done and your fellow workers.

Mr. IMBRECHT. We have only done that which the legislature and the governor have made possible.

Senator ROCKEFELLER. Said very nicely.

We are going to hear some skepticism today, and I thought it might just be interesting while you are here to get you to respond to some of that. And that is going to come particularly from Mr. Dixon Smith who is the General Manager of Chevron. And he and others in the oil industry will today and in the future raise a number of questions about alternative fuels, and I would just like to have you up front respond to some of the things they will be saying.

They say that alternative fuels are not practical economically. What say you? You have discussed a number of these things, but I want this in a question and answer form.

Mr. IMBRECHT. Well, this has been discussed in great detail and depth.

Let me say to you that I have no doubt whatsoever that methanol can be brought to market well within the delta or the difference in price that currently exists between low priced and high priced fuels in service stations throughout America today. That being the case, I personally cannot see any obstacle that would prevent the American public from embracing methanol as a desirable fuel largely because of its performance characteristics, but also with the knowledge that you are also assisting in reducing air pollution. We have many studies in California that suggest that our consuming public, in fact, are concerned about air quality and would, in fact, respond if they were provided the choice to do so.

Let me say as well that to the extent that the Federal Government decides to go forward with programs that ensure a minimal degree of penetration, that greatly eliminates the so-called risk factor that is the large unknown element and that the petroleum industry has quite consistently argued. If you have guaranteed demand for methanol fuel, the risk associated with a capital investment of new production obviously is diminished significantly.

And finally, let me just note as well that in the context of increased vehicle miles traveled, which surely must also be addressed, but in that context and in the context of closed refineries in the early 1980's, it is quite clear that in many regions of the United States today that we have a very tightly stretched refinery capacity just to meet gasoline requirements. I think it should be obvious in that context that if the petroleum industry then must, in fact, make capital investments, add additional refinery capacity to meet expected growth in demand for liquid fuels, surely the substitution of one capital investment for another does not result in the kind of dramatic and barrier source of hurdle rates in terms of investment that we have heard argued from some within the petroleum industry.

Senator ROCKEFELLER. You mentioned a moment ago the Carnegie study. Chevron's interpretation is that they say it seems to cite that there are no benefits in terms of ozone. How do you explain that and what do you think that the study says?

Mr. IMBRECHT. I really don't have an adequate explanation for that. I will only say to you that we are quoting from the authors of the report and from the agency that was responsible for contracting for the report to be conducted. And in terms of a general application of the best evidence rule, it seems to me that those that have responsibility for the report and were responsible for conducting it, in fact, should be the best authority upon which to rely in terms of interpreting the results. And I would urge you, if you consider this to be an open and debatable question, to turn to the best source and invite the authors of the report to present themselves. And I am sure you will find that their conclusions are adequately and accurately reflected in my testimony.

Senator ROCKEFELLER. They say that their consultants have shown that alternative fuels do not improve air quality any more than can be achieved by improvements in the gasoline engine.

Mr. IMBRECHT. Well, I guess the question I would pose is then where have we been for the last 20 years. We have heard the arguments about cleaner gasoline, and we certainly support efforts to achieve cleaner gasoline. We want to see emissions from whatever approach is most useful—in fact, as I said earlier, in my judgment we are going to need to pursue all of the approaches, alternative fuels as well as improved gasoline, because obviously for many years in the future, gasoline will continue to be the dominant fuel in the transportation marketplace, in fact, well into the point where I can possibly look into a crystal ball.

But aside from that, we have not seen the kinds of development in terms of clean gasoline and demonstrated results that we have today with alternate fuels. And are encouraging additional efforts in that regard and research and development, et cetera, but to suggest that we should stay our effort to pursue alternate fuels while we wait for clean gasoline to catch up doesn't strike me as being a reasonable tradeoff in the realm of public policy, particularly when you look at health impacts as well as public concern about our air quality.

Senator ROCKEFELLER. They say that formaldehyde emissions—and you have touched on this—are a strong argument against methanol. And they also raise the specter of toxicity even with respect to its effect on the skin.

Mr. IMBRECHT. Okay. First with the respect to formaldehyde, I think I did address that, but let me say that I would urge the Federal Government and the Environmental Protection Agency to do just what the California Air Resources Board has done and that is to drive and push technology, set a formaldehyde tailpipe emissions standard which is equivalent to a gasoline formaldehyde emission, and then also capture the benefits of lower reactivity of methanol hydrocarbons in terms of lower atmospheric formation of formaldehyde. And in that sense you get the best of both worlds.

Secondly, as I indicated, the Carnegie Mellon study shows net reductions in formaldehyde atmospheric exposure. In any case, the levels of exposure are very, very low, about one one-hundredth of what is viewed by health authorities as posing a health risk for the average citizen.

With respect to toxicity, we have heard arguments about skin absorption and so forth. The bottom line is that you are talking about extended skin absorption, in the neighborhood of leaving your hand or arm in a bucket of methanol for many, many hours before there is any possibility of health effects from skin absorption. I would suggest to you that if you left your hand in a bucket of gasoline for many, many hours, you would find equally negative health impacts. In fact, I would suggest that you probably wouldn't have much in the way of your dermal or skin left.

So, I think it is important, as we look at any of these issues, to look at them on a relative basis. It is not methanol against a perfect alternative; it is methanol against or versus the status quo. There is no dispute that both substances are, in fact, chemicals that must be treated with respect and with care, and it is clear that the petroleum industry already provides that advice to their service station operators for mitigation of liability, if for no other reason. And that same kind of training and application clearly provides similar protections with respect to methanol.

We have had it in general circulation now since 1983. Everyone from clericals from executives in State service and local governments have used methanol, have self-served their vehicles, et cetera with absolutely no reported incidence of health impact or public exposure or danger.

And finally, I would just note that both the President and the Governor of California have both self-fueled methanol vehicles at our demonstration dedications, and I doubt very much if the people that are responsible for protecting them would have allowed them to be exposed to an inappropriate health hazard.

Senator ROCKEFELLER. I have here the private agreement between your commission, Chuck, and General Motors that says VFVs, which are variable fuel vehicles, covered under this agreement will be required to satisfy California Air Resources Board requirements as specified in Exhibit 1. Does that not mean that GM has promised to meet California standards on formaldehyde?

Mr. IMBRECHT. Yes, that is our interpretation of the document, and I have not heard any contrary interpretation.

Senator ROCKEFELLER. They say that alternative fuels can't help, particularly energy security.

Mr. IMBRECHT. Well, I will fully admit to you that that is probably a more esoteric argument and one which obviously has to be based upon personal judgments.

It just seems to me that sheer logic alone would suggest that if the United States could turn to better than 40 potential sources for its transportation fuel feedstock as contrasted with 20 today, that the security and the aversion to the likelihood of cartels and ethnically driven cartels, et cetera is greatly, greatly diminished. We believe diversity of supply, in fact, is a fundamental building block for energy security.

And finally, I would just note that from a price standpoint as well, isn't it about time that we provide the motorists of the United States the benefits of fuel-on-fuel price competition as, for example, the utility industry has enjoyed for the last decade or so? It is obvious that if you have multiple fuels competing in the transportation network and if you believe in a free market at all, that there will, in fact, be a breaking or leveling impact as between the fuels, and that in turn will also provide equilibrium vis-a-vis fuel price.

Senator ROCKEFELLER. And it is interesting, I think, to note that the Department of Energy agrees with what you have just said.

Mr. IMBRECHT. Yes, that is correct.

Senator ROCKEFELLER. Chuck, you were obviously very, very supportive of our efforts last year to break the so-called chicken and egg cycle where we entered, and we entered into the automobile part of it on our CAFE credit bill.

What other improvements in your judgment are there to wider use of alternative fuels, and what other efforts do you think that the Government ought to be making?

Mr. IMBRECHT. Well, without being repetitive, I tried to touch on a number of those at the conclusion of my testimony, and you will find them outlined including, first off, full funding of your legislation is critical; secondly, increased research and development activities with some of the technologies that are not quite ready for the commercialization that we see for the flexible fuel technology because they are not that far away that they cannot provide very important benefits and applications for the United States in the mid and latter part of the 1990s.

But aside from those particular items of fuel tanks and service stations and so forth, let me stress again that we do believe that it would be useful for the Federal Government, in cooperation with the states, to pursue a complementary incentive for the other side of the equation. The Alternative Motor Vehicle Fuels Act dealt with the vehicular side, and if we can provide a similar incentive from a regulatory standpoint for the fuel side, I think that would certainly assist us in a great sense in reaching our goals.

And I would urge that such an approach be based upon performance. I absolutely agree with the petroleum industry. It should not be directed at mandating a given fuel. I think that all fuels should be driven to be substantially cleaner, and I would suggest that you might want to start with something to the effect that you are talking about standards that would be at least as clean as methanol and, if in fact gasoline can achieve that, then I think we ought to applaud that kind of a development.

Senator ROCKEFELLER. Which gives them the opportunity to approach it however they want.

Mr. IMBRECHT. And moreover, if it can be done in a fashion to provide an incentive for capital investment in new methanol production, it solves two problems at the same time. Let me offer a little more detail in that context.

If one of the ways—and I think one of the clear options available to clean gasoline is to reduce aromatic content and that, in turn, requires another octane enhancer which is likely to be one of the alcohol or alcohol derivatives such as ETBE, MTBE or ethanol itself, that in turn provides a substantial incentive for the petroleum industry to invest in new production because in addition you will have an assured market and therefore that risk issue again is diminished.

We calculate in California that if you were to use MTBE, for example, that would drive a demand for about 700 million gallons of methanol as a feedstock annually. If you use our hypothetical of a 1.2 billion gallon annual output methanol production facility as being the best to capture economies of scale, you would obviously provide a demand for better than half of its output and free up 400 million or 500 million gallons for the early stages of an M85 or neats fuel application in buses and heavy duty applications. So, all of that to us seems to dovetail reasonably well together.

What we have tried to say to the petroleum industry is that we put this option forward for you. Thus far several of the companies are quite positive about it. Others continue to be skeptical in all honesty. What we have tried to stress is that we have made a proposal. If you do not care for this one, then the ball is in your court. Offer us an alternative and we will certainly give it every consideration. And we continue that approach today.

Senator ROCKEFELLER. Chuck, one of the things I am very strongly considering is precisely legislation. I think legislation tends to focus the mind.

I recognize that some of these things that I am asking you you referred to, but there is something about a question and answer that is useful. I am giving you a long time because I want specific answers from you as you would choose to give them.

Here inside the beltway, we are beginning to hear a lot of rumblings at last about the so-called California debate over mandated use of alternative fuels like the approach of a distant thunderstorm. What is California requiring? Is it possible to achieve the clean air benefits of alternative fuels through legislation that uses a carrot instead of a stick or at least that doesn't include outright mandates?

Mr. IMBRECHT. Well, I have made it abundantly clear from the outset of these debates and discussions that I personally would greatly prefer to approach this issue without mandates. In fact, I think that we should only turn to mandates as a fallback position. And that is why we have encouraged efforts to discover a comparable incentive for the fueling side of the equation.

And let me just say that on a preliminary basis, the Governor's Advisory Board has circulated for public comment a proposed implementation plan that would, in fact, embrace fuel pool averaging with a "triggered" mandate fallback. In other words, we would define a certain level of desirable penetration of alternate fuels. And if the incentive approach achieved sufficient penetration, that obviously would be acceptable, and if it did not, after a period of time, perhaps 5 years, that would in turn trigger required penetration availability of vehicles on fuel.

And I would note while at this point I can only quote for you the public record, three representatives from the petroleum industry that are on the board did vote affirmatively for circulation of that proposed implementation plan. I have heard some suggestions they might have second thoughts, and perhaps Mr. Smith will address that later.

Senator ROCKEFELLER. The interest in alternative fuels obviously has picked up here and elsewhere. And as that has happened, there is going to be some jockeying for positions, so to speak, among advocates of various kinds of alternative fuels or various alternative fuels.

My own view is that—and clearly it is yours because you have expressed it, but I nevertheless direct this question—we should use all and everything available to us.

Mr. IMBRECHT. All of the above.

Senator ROCKEFELLER. Right, all of the above and whatever adds on to that that makes sense. Each may play an important view. Please respond to me formally as to your view.

Mr. IMBRECHT. Without question, each can and should play an important role. And today we can define very clear applications for each of the fuels which you enunciated and, as I indicated as well, my testimony also talk about applications for propane.

Very simply, we would expect with or without the application of the tax incentive to ethanol to go to ETBE feedstock issue. With or without that, we think ethanol was likely to be a oxygenate feedstock for additives in those regions of the country.

I have already talked about methanol sufficiently I think.

CNG in our judgment makes a lot of sense for heavy duty applications in urban areas as well as for dedicated vehicles that are coming back to common fleet fueling. And there is a lot of interesting developments, I might add, as well in terms of personal compressors and so forth that also suggest the possibility that CNG could have even broader applications in the future.

And finally, in terms of electric vehicles, with the one proviso that they be recharged off peak, it is a very efficient utilization of our existing capital investment in electric generation resources around the United States. It is obviously a very attractive air quality strategy, and particularly in terms of delivery vehicles, mail vehicles, those kinds of things in urban settings, we can't see any reason why you can't go to electric vehicles today.

Senator ROCKEFELLER. And we are not talking, as I think many people would imagine, of something that can go 20 or 25 miles an hour. We are talking about 55 to 60.

Mr. IMBRECHT. We are talking about 50 to 55 miles an hour, perhaps even a little faster than that, and a range of between 60 and 100 miles. And we have looked at the mail fleets, for example, and they typically drive less than 30 miles a day. And I am talking about the small jeep-like vehicle that you see in most American suburban neighborhoods.

Senator ROCKEFELLER. One of the interesting coalitions that developed in this bill is represented on the dias today. Ethanol and methanol had apparently been fighting.

Mr. IMBRECHT. Most unfortunate.

Senator ROCKEFELLER. Well, that was stopped, at least for the most part, by Tom Daschle and myself because we made an agreement at the beginning of this bill that there was a tremendous amount of room for ethanol, a tremendous amount of room for methanol, natural gas, all kinds of alternatives, and that we were going to work together in harmony. And we did that. And it seems very propitious that Tom Daschle has just emerged on the scene, and I would ask for any comments that Tom Daschle might have.

Mr. IMBRECHT. Mr. Chairman, sorry to interrupt. Do you have further questions for me?

Senator ROCKEFELLER. I do not. Do you have a plane to make?

Mr. IMBRECHT. Might I be excused? I do have a plane and I need to excuse myself.

Senator ROCKEFELLER. With lots of kudos. Godspeed.

Mr. IMBRECHT. I appreciate very much the opportunity to testify before you. Senator, excuse me.

Senator ROCKEFELLER. Thank you, Chuck.

STATEMENT OF HON. THOMAS A. DASCHLE, U.S. SENATOR FROM SOUTH DAKOTA

Senator DASCHLE. Mr. Chairman, I want to thank you for giving me an opportunity to be here.

I mean this sincerely. I do not think there is a person in the U.S. Congress today who has had a greater impact on alternative fuels, especially in the last couple of years, than the chairman of this subcommittee, you personally. Your bill last year was a landmark piece of legislation that will do phenomenal things to the continued development and growth of the industry, and I applaud you for that leadership.

You are right. Up until the time that we decided that ethanol and methanol no longer had to be in competition with one another, there was too much in-fighting. The old saying that if ever the alternative industry organized a firing squad, they would form in a circle is absolutely true. They would have formed in a circle. But thanks to your leadership, that isn't happening anymore.

I am in the middle of the last hearing of the Special Investigations Committee on Indian Affairs, and we are finishing up this afternoon. But I feel so strongly about what you are doing and the importance of this hearing that I wanted to come by and make a couple of remarks.

I would like to have the remarks of Robert Reynolds, the President of Downstream Alternatives, to be inserted in the record following my statement.

Senator ROCKEFELLER. That will be done.

Senator DASCHLE. I think that in the last year in particular there is a greater realization than ever before that the true cost of hydrocarbon gasoline has been underestimated all the way through as we have considered the cost of energy today. It has taken Prince William Sound. It has taken a realization of the impact that benzene is having on toxic air. With this debate on trade, it has certainly taken a much greater appreciation of the tremendous percentage of the value of our trade deficit as it relates to oil imports to realize that the cost of hydrocarbon gasoline today is extremely high, in fact, untenably high. And so, the illusion that we have had over the last few years that there has been a cheap oil policy in this country and that we have benefited by it is largely being dismantled.

And as that illusion evaporates, we have a much better environment within which to consider alternative energy than ever before. And as we consider alternatives, the fact is that we can no longer wait to develop these in policy to the extent that we see that need.

The obstacles that have been cited in the past with regard to the development of alternative fuels, both real and imagined, are no longer viewed as insurmountable obstacles. General Motors has certainly represented that fact in their recent announcement that they are now going to recommend—not just tolerate, but recommend—the use of oxygenated fuels in their cars in 1990. That is a major development.

And as GM goes, so goes the industry in my view, and as we see the industry, so goes even additional policy here in the Congress. As we consider policy in 1989 and in the 101st Congress, I think there are a number of specific issues that have to be addressed to see this progress continue.

The first in my view is that it is imperative that we continue to extend blender credit and excise taxes. Mr. Reynolds addresses some of these, and I hope that we can pay special heed to his recommendations.

Secondly, I believe that discriminatory advertising cannot be tolerated both with regard to the differences within which we now treat oxygenated fuels, but also, and more importantly, the difference between ethanol and benzene as it is treated in the retail markets today. I think it ought to be noted that benzene is a poisonous gas and benzene is now found in the fuel that is a retail product in most parts of the country.

My interest has largely been ethanol. I think we are going to see a continued expansion of the ethanol market. Seven percent of the gas sold today is ethanol. But as the Chairman said so well, this is no longer an ethanol issue. It is no longer a methanol issue. It is an alternative energy issue. If methanol and ethanol and the other alternative energy forces join together, I have absolutely every confidence that we can continue to improve our position in public policy and look forward to a lot more significant and consequential effect of these policies in the near future.

In that regard, Congressman Sharp and I have asked the General Accounting Office to look at the need for continued isobutylene investment tax credits and their ramifications with the increasing demand of feedstocks and other ramifications in public policy that we will look at as we consider tax credit.

Once again, Mr. Chairman, were it not for your interest and your leadership and the tremendous strides that we have made as a result of that leadership in the last couple of years, we couldn't look with the confidence we do today. I am encouraged by that. I want to offer you my utmost cooperation and I must tell you that I think there are even better years ahead.

[The prepared statement of Mr. Reynolds follows:]

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Testimony of

ROBERT E. REYNOLDS
PRESIDENT
DOWNSTREAM ALTERNATIVES INC.

before the
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

JUNE 6, 1989

Mr. Chairman, my name is Robert Reynolds and I am President of Downstream Alternatives, Inc. I appreciate the opportunity to be here today to testify on behalf of my firm on steps that our nation can take to expand the use of alternative fuels.

Downsteam Alternatives Inc. is a consulting firm specializing in the areas of alternative and renewable fuels as well as oxygenated fuel blends. In this capacity we provide consultation services to a number of clients involved in the motor fuels business as well as the automotive service industry. I should add that in addition to over two years as a marketing manager for a major ethanol producer, my background encompasses 15 years of petroleum industry experience including administration of a special fuels program that included both ethanol and methanol blends as well as a neat methanol fueling facility. This special fuels program exceeded 300 million gallons per year. These experiences enable me to comment on the impediments that exist to the alternatives fuel industry, not as an observer but as a participant.

In preparing my comments for today's hearing, I received a number of documents identified by Senator Rockefeller's office as potential items to stimulate discussion. Although I will limit my oral comments to ethanol related issues, I have included my observations on those documents, as a supplement to my oral testimony.

Unlike many of the alternative motor vehicle fuel options in the United States, ethanol has already established itself as a viable motor fuel alternative. It's contributions in a number of areas are already well established. In addition to it's ability to reduce dependency on crude oil and create markets for agricultural surpluses, ethanol has established itself as an environmentaly benign component of gasoline. Not only has it been used to replace lead as an octane enhancer, but it is used as an oxygenated fuel component to reduce tailpipe emissions of carbon monoxide. Ethanol can also be viewed as a high octane component that could replace harmful aromatic components in gasoline.

With ten years of use, ethanol blends now represent over 7% of the U.S. motor fuels market. Therefore unlike many other alternative fuel options, the methods to encourage increased production and utilization of ethanol can be based upon experience rather than supposition or hypothesis.

Basically the steps that could be taken to expand the fuel ethanol industry can be placed in one of three broad categories; public policy uncertainties, technical considerations, and marketing issues.

Public Policy

Currently the ethanol industry is faced with a number of uncertainties that restrict growth. Key among these is the expiration of the 6¢ motor fuels excise tax exemption for ethanol blends and whether or not ethanol blends will receive a waiver from fuel volatility restrictions when the EPA implements phase II of their fuel volatility reduction plan.

The lead time to build a commercial size ethanol plant is 2 to 2.5 years. This means any plant conceived today could not be on line before late 1991, just two years before the excise tax exemption expires. Without the exemption, plants cannot project adequate return on investment so no new plants are likely to be built. Even plants planning production expansions are finding the time frame for investment recapture to be insufficient.

•To encourage expanded production and use of ethanol blends, it will be necessary to extend the 6¢ motor fuels excise tax exemption and the 60¢ blenders credit until the year 2000 or beyond.

The possibility that ethanol may not receive a fuel volatility waiver is also restricting growth. Currently ethanol is generally added at the petroleum distribution terminal as part of the quality control process to avoid moisture contamination. This practice generally results in a fuel that is slightly more volatile. Although everyone in the industry wishes this were not so, such is the case. It is widely accepted that no alternative to these blending procedures currently exist. Therefore if the EPA were not to grant a Reid Vapor Pressure (RVP) waiver to ethanol blends under phase II of their rulemaking, virtually all ethanol blending will cease. It is obviously difficult to encourage growth in the face of such possibilities.

•This issue can only be overcome by ensuring an RVP exemption to ethanol blends in any future regulatory or legislative initiatives.

Technical Issues

The aforementioned procedure of blending ethanol at the terminal level results in several technical impediments. This procedure results in special handling and logistic considerations that not only increase distribution expenses but also limit expansion of ethanol blends, because unlike other gasolines, they are not treated as a fungible product for shipment by pipeline, or product exchanges.

Additionally while all automakers continue to include the use of ethanol blends under vehicle warranty coverage, they stop short of full endorsement because the addition of ethanol to specification fuels at the terminal will increase fuel volatility slightly.

One solution to these problems is etherification of ethanol to ethyl tertiary butyl ether (ETBE). Converted to an ether, ethanol could enter the gasoline pool at the refinery for shipment via pipeline. Additionally ETBE would lower the Reid Vapor Pressure of the gasoline to which it is added while providing an octane increase. Although ETBE's oxygen content is lower than ethanol's it is still sufficient to provide a significant reduction in tailpipe emissions of carbon monoxide.

Despite these positive attributes, the ETBE issue has polarized the industry unlike any recent topic. Everyone in the industry believes that developing an ETBE strategy would be beneficial. The disagreements center around the level of benefit and the method of achieving it. This is largely because information concerning ETBE has been over-simplified, exaggerated, distorted, and in some cases just plain inaccurate.

In an effort to promote an ETBE strategy, some proponents have failed to look beyond its positive attributes. However like any new article of commerce, there are other considerations. Those include production economics, co-feedstock availability, logistics, automotive issues, true market potential, and public policy considerations. While it would be too time consuming to cover these here today, I have included a two-part article with a supplement to my testimony. This article identifies the issues in each of these areas.

It is important to understand that for an ETBE strategy to be successful, a healthy ethanol industry is required. Production and marketing of ETBE will not occur overnight.

One need only look at MTBE to confirm this. Manufactured by the oil companies who control the feedstock and end product markets, U.S. MTBE production has grown to over a billion gallons in ten years. A similar growth pattern for ETBE would result in 400 million gallons per year of ethanol used as ETBE feedstock. This is less than 40% of current industry capacity.

This is not to say that ETBE development should not be encouraged. It should be, but not at the expense of continuing to develop an ethanol industry while ETBE develops it's market as a fuel component.

Congress should not consider ETBE as an immediate replacement for ethanol. ETBE should be viewed in the context of a long range developing product that will enhance the market for ethanol.

•To encourage the production and use of ETBE, the definition of the blenders tax credit should be expanded to include ether manufactured from ethanol. Additionally congress should consider directing the DOE to initiate projects to address the many unanswered questions as well as research and development projects to accelerate its production and use.

Marketing & Public Perception Issues

Despite ten years of use and 700 billion miles, the ethanol industry continues to battle a misperception of the quality of ethanol blends.

There are three major contributors to this problem. The first problem is the requirement to label pumps disclosing the presence of ethanol. Being the only gasoline ingredient other than lead that requires a label, this disclosure is often perceived by the consumer as some type of warning. This perception is further magnified where states implement pump labeling regulations that require punitive labels with ridiculous requirements such as two inch lettering, black on yellow.

These labeling requirements foster the second problem which is anti-alcohol labeling by certain oil companies. Once labeled with what is perceived to be a warning, oil companies need only advertise that their products contain no alcohol to further feed the perception that alcohol fuels are bad.

•If congress wishes to encourage expansion of alcohol fuel blends, it should consider a pre-emptive pump label that is reasonable, consistent, and treats all fuel components equally.

The third problem is the fuel statements contained in vehicle owners manuals. Wording pertaining to ethanol is often overly cautious and at best confusing to the consumer.

While these statements cannot be regulated out of existence, public policy could encourage the automaker to treat ethanol blends in a more positive fashion.

•One such option would be to grant CAFE credits to those automakers who encourage the use of EPA approved fuel components which are not petroleum derived. As an example automakers recommending the use of ethanol could receive CAFE credits equivalent to a factor of their fleet operating on the national sales average of 7% ethanol blends. This would enable the automaker to calculate their CAFE compliance assuming that 0.7% of all fuel used is non-petroleum based.

Summary

In conclusion, there are a number of steps that our nation can take to encourage the production and use of ethanol and ethanol blended fuels.

•Extension of the 6¢ motor fuels excise tax exemption and the 60¢ blenders credit to the year 2000 or beyond.

•Ensure that ethanol blends receive an RVP tolerance allowance from fuel volatility regulations.

•Expansion of the definition of the blenders credit to include ETBE produced from domestic ethanol.

•Direct the DOE to engage in projects to quantify the open technical and marketing issues surrounding ETBE and to engage in research and development projects to accelerate its production and use.

•Initiate legislation to establish a national uniform pump labeling program that treats all fuel components in an equal fashion and preempts state labeling.

•Allow automakers which promote renewably derived EPA approved fuel components to take CAFE credits proportionate to their market availability.

I appreciate the opportunity to offer these comments and would be pleased to answer any questions you may have.

Thank you.

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Supplement to Testimony of

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before the
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

JUNE 6, 1989

In preparation for the above referenced subcommittee hearing, I reviewed 5 documents identified by Senator Rockefeller's office as possible topics to stimulate discussion. Time limitations do not allow sufficient time to comment on all of these topics, so I have included my observations on these documents with this supplement to my testimony. The five documents reviewed are as follows:

- Submission from Southern California Edison
- Submission from American Gas Association
- Response from Department of Energy
- Understanding the Challenges & Future of Fuel Alcohol in the United States
- Legislative Options to Promote the Use of Alcohol Fuels (CRS-3/89)

In addition we have included a two-part article entitled "ETBE: Merits, Myths, & Misgivings" which was written by me for Fuel Ethanol Monthly. Fuel Ethanol Monthly is published by Downstream Alternatives Inc. The article is included to present the numerous considerations that would be involved in developing an ETBE strategy so that ethanol could enter the gasoline pool via the etherification process.

Submission from Southern California Edison (SCE) March 31, 1989

The electric vehicle (EV) industry is currently confronted with two obstacles that restrict the proliferation of EV's. The first is vehicle cost and the second is a perception that the vehicles are slow and undependable.

With vehicle costs in the $30,000 range it is likely that the government will find it necessary to take steps to encourage large scale demonstration fleets such as the program in California for flexible fueled methanol vehicles. Large scale fleet demonstrations would not only reduce vehicle production costs slightly but they would contribute to technological advancements, while at the same time assist in overcoming the image that EV's are slow and unreliable.

From an environmental standpoint, environmentalists will want to see data that correlates energy plant emissions output to EV miles driven. The government should require some analysis in this area as results should be favorable and would encourage more wide-spread support.

Submission from American Gas Association (AGA) April 14, 1989

Essentially I agree with most of the comments included with this submission. A few items that should be explored further are as follows

- With technically recoverable known resources of natural gas equivalent to 60 years supply, accelerated use would result in a much shorter supply time span. Therefore while there may be significant environmental contributions from an energy standpoint, we may only be buying time. Additionally the cost of furthering the use of natural gas vehicles must be weighed against the availability of the fuel over a relatively short period of time. By the time vehicles would be widely available, supplies will have diminished further.

- The distribution system will unquestionably be a significant impediment. Approximately 80% of U.S. gasoline customers purchase their motor fuels on a self-serve basis. A distribution system to fuel NGV's would probably require a return to full service operations for safety and insurance considerations. This could result in reluctance to stock the fuel because of the perception of higher labor costs.

- Any effort to expand the use of NGV's will require a comprehensive educational effort among the fleet management community. Such a program should demonstrate the benefits and considerations of a switch to NGV's. In addition any effort to expand NGV's into the consumer market would require not only an educational effort to address the misperception about natural gas fueled vehicles but likely would require some type of up-front motivation such as a significant tax credit for purchase of NGV's.

•The creation of a National Center for Alternative Fuels is an idea whose time has come. Such a center could accumulate all of the data on the various alternative fuels and provide a data base for decision makers in both government and industry.

Response from Department of Energy (DOE) March 20, 1989

Many of the alternative fuels research projects underway at DOE are in areas where my firm is either not involved or involved on a limited basis. While all of these projects seem to have merit, I will limit my comments to those following areas where we have a level of familiarity.

Alcohol Fuels from Biomass: In order for the ethanol industry to grow and expand, second generation ethanol plants will need to incorporate a number of technological advancements. Therefore research which improves yield, decreases resident fermentation time and reduces catalysts cost is very important. This is especially true when considering feedstock other than those traditionally used.

Supply & Benefits Analysis of Alternative Fuel Use in Transportation: When trying to encourage involvement and investment in alternative fuels and alternative fueled vehicles, projects such as this are very important. In order to accurately demonstrate the benefits of such programs it will be necessary to assess the impact on oil imports both as to national security and trade deficit issues. Other benefits such as environmental impact and economic activity generated should also be considered.

Alternative Fuels Market Development: Any new fuel concept will meet significant market barriers. To properly assess these impediments and formulate policies to address them may require an expansion of this project. Potential fuel sources cannot be assessed individually but must be assessed collectively along with existing motor fuels. Methanol, CNG, electricity, ethanol, petroleum, and possibly hydrogen will all compete in the same market place. The market growth of each will be affected by other alternatives available in the market place.

Methanol Fuel Infrastructure Assessment: Without question one of the greatest obstacles for widespread use of methanol as an alternative to gasoline will be achieving a level of distribution that allows the customer easy access to the fuel. An example of this is the poor sales of diesel automobiles in the 1970's because of a perception of inability to easily obtain the fuel. This study should also determine the type of incentives that may be required to encourage operators of retail outlets to make the necessary investment to handle methanol.

Environmental, Health & Safety Impacts of a Flex-Fuel Transportation System: Because any methanol used for flex-fuel or alternative fuel programs would hopefully come from our nation's abundant coal reserves , it may be desirable to expand the EHS assessment to include the fuel source. Some opponents of methanol fuels are already arguing that the environmental negatives of methanol from coal exceed the benefits.

Other Projects to Consider: In addition to the projects currently underway there are other areas on which the department may wish to focus. One example would be conversion of methanol to gasoline (Mobile MTG process). While this may not provide the environmental benefit of using methanol itself as a fuel, it does provide an avenue for methanol to enter the existing motor fuels infrastructure.

For the longer term, many experts have advocated the use of hydrogen. In fuel form hydrogen is 15 to 45% more energy efficient than gasoline. It can be cleanly extracted by means of solar energy and is the most common element in the universe. Any comprehensive energy analysis and research should include a review of the potential for hydrogen as an alternative fuel.

In the case of ethanol, the department may wish to expand research to include etherification to ethyl tertiary butyl ether (ETBE). The use of ETBE as a gasoline component provides numerous benefits. ETBE is only slightly soluble in water, thus allowing for addition to gasoline prior to pipeline shipment. It is a high octane component but has a low vapor pressure thus providing refiners a method of maintaining octane quality without increasing gasoline volatility. Although ETBE does not contain as much oxygen as MTBE or ethanol, the oxygen content is still sufficient to provide significant reductions in tailpipe emissions of carbon monoxide. Lastly since ETBE is comprised of approximately 40% ethanol, its use would still promote the use of a renewable component in the gasoline pool.

The ETBE issue has become somewhat polarized because of misstatements, misinformation, exaggerations and oversimplications. An accurate and unbiased assessment of the potential for ETBE would provide decision makers in both government and industry the information they need to determine what course of action to take concerning this product.

Understanding the Challenges & Future of Fuel Alcohol in the United States (prepared for US DOE Office of Alcohol Fuels)

Some sections of this report indicate detailed analysis and research which accurately portray the topic of discussion while other sections clearly show a bias not supported by fact and/or an unfamiliarity with the subject matter.

This report portrays the ethanol industry leadership incorrectly. In its assessment of the industry leadership, the report criticizes the tendency of producers concentrating their sales efforts in states with incentives, portraying this strategy as if it were a "fast buck" approach. The report states that "the industry became too customized to the profitability offered by combining state tax incentives with federal tax support". Of all the characterizations one might attribute to the ethanol industry, fast or easy profits are not among them. In most cases this strategy of selling in markets that offer the highest price was simply one of survival. Even if it were not, limited partners and stockholders are not likely to approve of a strategy that directs product at a market that provides lower profits and perhaps even losses. While it may be governments job to develop or direct such activities, industry's function is to turn a profit.

The report also portrays industry management as having "sought to maintain an image that fully satisfies only one aspect of the fuel alcohol industry's possibilities". It goes on to say that "other ethanol participants, concepts, or marketing approaches have been rejected". It is true that the domestic ethanol industry has attempted to protect themselves from heavily subsidized imports which are imported under tariff circumvention schemes to take advantage of both U.S. Customs and the motor fuel excise tax. This does not however justify an image of rejecting participants, concepts, or marketing approaches nor does it give industry leadership credit for the many positive steps it has taken.

The domestic ethanol industry has welcomed the construction of new plants, realizing that new players bring an element of growth which is necessary for long term survival. The industry is also on record in support of full fermentation based ethanol production facilities in the Caribbean Basin despite the additional competition this support could foster.

As to concepts and marketing approaches, the industry has taken ethanol from the concept of a patriotic gasoline extender to that of an octane enhancer, a replacement for lead in gasoline, and an environmental tool.

The report gives industry leadership no credit for marketing or educational efforts taken over the last ten years. Nor does it point out that these efforts were at times put forth during periods of oil company attacks, droughts, collapsing crude prices, and other crises.

The report also oversimplifies several issues especially in its assessment of oil industry acceptance of ethanol and the potential market for ETBE.

While the report correctly points out certain marketing obstacles for ethanol, such as water sensitivity, manufacturing locations, etc., it overlooks several very important facts. First is simply the issue of profitability. Ethanol is not manufactured by the oil industry and therefore is a choice of last resort in many cases. Refiners are in the business of manufacturing finished products from crude oil. Profits are made from crude oil and refining. Periods of time characterized by low crude prices and/or high refining margins result in refiners utilizing there own resource first. The industry has functioned in such an environment for the past several years. Even with some of these other obstacles resolved, refiners will not use ethanol unless it either offers more profit than their combined profitability from crude production/refining margins or unless gasoline demand exceeds refining capacity.

In the case of ETBE, the report drastically oversimpifies the development of this product without addressing cost of production, purity of feedstock, capital investment, competitive factors, co-feedstock requirements (i.e. isobutylene), logistics, marketing/customer base considerations and numerous other technical considerations.

The report also states that "the fuel ethanol industry has failed to implement strategies designed to assure prospective oil industry customers that the required volumes would be available on a reliable basis". Presumably it is to be believed that the industry can change the economic realities of crude oil being priced below $20.00 per barrel in recent years. The inability of the industry to grow in the past few years is the result of several factors including:

- Insufficient profitability to recapture investment due to the 1993 expiration of the 6¢ motor fuel excise tax exemption and adverse marketing conditions.

- Low crude oil/gasoline prices and resulting lower ethanol prices.

- Inconsistent public policy on ethanol imports and tariff circumvention schemes that give importers an unfair advantage.

The report also incorrectly implies that EPA's decision to eliminate the Evaporative Index (EI) requirement from the DuPont waiver makes commercialization of this blend possible. In reality the vapor pressure increase from this blend would result in such a large butane debit that it may never achieve commercialization regardless of methanol prices. The same would apply to Octamix formulations.

Additionally the report errs in its assessment of volatility controls on ethanol blends. No one would dispute that, from a technical standpoint, an ethanol blend meeting the volatility standards of other hydrocarbon gasolines would be an improvement. The report states; "Imposition of a uniform volatility standard for all gasolines would have the additional consequence of discouraging the industry practice of adding 10% ethanol to already finished gasoline for simple margin improvement. The industry would be forced to consider production of a low-RVP/octane basestock or refinery-type blending for attainment of target octane and vapor pressure."

The above statement demonstrates that the report authors are totally unfamiliar with the dynamics of the logistics involved in petroleum distribution. I have manufactured and shipped sub-octane gasolines (both pipeline and barge). If one volatility standard applies to all fuels, refiners would not be forced to consider sub-RVP/octane strategies. They would simply be forced to cease selling ethanol blends.

The report also errs in its assessment of alcohols as octane enhancers as well as its hydrocarbon and oxygenate price forecasts. The report assumes the availability of a fuel with a 6.2 psi Reid Vapor Pressure, with an octane of 85

R+M/2. No refiner would voluntarily make such a fuel, some could not do so if they were so inclined.

The projections for crude oil prices and gasoline prices (on which alcohol & MTBE prices are based) are not realistic. Gasoline prices projected compared to crude prices projected would require refinery margins of over $20.00 per barrel of oil by 1995 in the low case and nearly $30.00 per barrel in the medium case.

The report is heavily biased towards one approach, i.e. ETBE. The conclusions about the potential for ETBE are not based on quantitative analysis but on opinions and incomplete information. No quantitative data if offered in support of the assumption. In many cases the qualitative assessments indicate an unfamiliarity with the refining industry and the unique considerations involved in the supply and distribution of petroleum products.

Since there are a number of inaccuracies and biases in the report and conclusions and recommendations are offered without quantitative analysis, this report should be considered as informational only. The report should not serve as a definitive tool in any policy decision without substantiation from another independent study group.

Legislative Options to Promote the Use of Alcohol Fuels (Congressional Research Service) March 9, 1989

The CRS paper presents a number of options with promising potential to aid in the expansion of alternate motor fuels

Mandate Output Mix in Motor Fuel Production: A mandate output mix would impact various companies and refineries differently. The level of impact would depend on the sophistication of their manufacturing process as well as whether or not they were net sellers of crude oil, finished products, and octane components. Mandates of this nature should be based on industry refining models and should be structured so as not to put disproportionate burden on any one segment of the industry.

As suggested by CRS, a trading mechanism minimizes problems with compliance. Any such trading mechanism should allow trading from one calendar quarter to the next since it would be difficult to determine compliance until after the fact.

If the fuels are oxygenated compounds being utilized for environmental reasons such as carbon monoxide (CO) reduction, trading should be limited within the non-attainment area so that environmental benefits are not jeopardized.

Feasibility Study of Government & Defense Sector Use of Alcohol Fuels: Federal Government purchases of alcohol fueled vehicles should be encouraged. In order to gain experience, improve technology, and overcome consumer concerns about such vehicles, it will be necessary to have large demonstration fleets. The only way to accomplish this in an industry still in its infancy, in through large government fleets.

Grants to Improve Methanol Production Technology: All steps possible to improve production techniques and to lower production cost should be taken . Any long term methanol fueled vehicle program should be based on methanol produced from U.S. coal. Methanol produced from coal must be relatively cost competitive. Otherwise a developing methanol fuels industry would be based on methanol imports and we would be trading one source of energy imports/energy dependency for another. (However developmental stages of the industry should not preclude the use of imports since to do so could impede the development of alternative fueled vehicles and modifications to the distribution system)

Restrict Imports of Methanol: The concern that restricting imports of methanol could restrict growth of methanol as a motor fuel are valid. On one hand abundant supplies are needed to develop a sizable methanol fuels market. On the other hand such a programs end goal should be to encourage growth of the domestic industry. One approach to address the dilemma could be to allow larger duty free imports of fuel methanol in the early years of a fuels program and gradually phase down imports by increasing the tariff over the period of program development. Such a program would maintain a level source of supply for market development but do so in such a way as to encourage an ever increasing portion of supply to be based on domestic resources.

Restriction of Crude Oil & Gasoline Imports: Without question, low priced crude oil and gasoline imports restrict the growth of alternative energy sources. More importantly they impact on national security and our trade deficit. Therefore any restriction on crude oil and gasoline imports should be viewed as an element of a national energy policy, not just as an alternative fuel strategy.

However such a national policy could include programs directly linking alternative fuels consumption to energy imports . Such a program might seek to encourage alternative energy use by requiring offsetting alternate energy sources for any crude or gasoline imports. Such a program would put the responsibility on the shoulders of those companies who would jeopardize our economy and energy independence by importing cheap foreign products.

As an example, any company importing crude or refined products could be required to utilize an offsetting amount (based on volume or BTU's) of alternative energy sources.

Strategic Methanol Reserve: The CRS observations that methanol would not serve as a strategic fuel during energy interruptions are valid. Additionally since methanol would require above ground storage tanks, it is not likely that sufficient storage capacity would be available. Even if available, such storage capacity would be extremely expensive compared to that utilized for the SPR.

Mandate Fuel Content/Mix to be Distributed: Any fuel content mix mandates should ensure that all fuels are directed at their highest value use. This necessitates an assessment of both environmental and energy considerations. Such mandates effect not only vehicle exhaust and evaporative emissions but also energy used in transportation to distant points as well as refinery emissions, gasoline composition, and characteristics.

Any trading mechanism established for fuel mandates should be restricted to trades within the non-attainment area to be sure benefits are incurred within the targeted area.

Loans & Grants for Production Facilities: The government's track record in this area has not been pleasant. It has been shown that the very cost of complying with requirements of obtaining loans and grants add significant cost to the project.

Improved Storage Technology: The vast U.S. petroleum distribution system handles several petroleum products. Due to the fungible nature of the system and the variety of methods for water to enter the system, it may not be possible to improve storage technology to eliminate moisture. It may be more feasible to direct research towards chemical methods of making alcohols less sensitive to water.

R & D to Reduce the Volatility of Alcohol blends: It should be pointed out that the CRS report is in error in characterizing most alcohol blends as being currently marketed by addition to sub-octane gasolines. Sub-octane gasolines are largely unavailable throughout the U.S. Current blending practice generally results in the alcohol being added to a finished specification gasoline at the terminal. Nonetheless this is one of the most important areas for research. The auto makers have expressed concern about the effect higher volatility fuels have on vehicle driveability. Evaporative emissions could be further reduced if fuel volatility were lowered. Any program that results in lowering the volatility of gasoline/alcohol blends would contribute to the marketability of these fuels.

One of the simplest routes would be etherification such as converting ethanol to ETBE however other avenues should also be explored.

Lower Volatility Standards for Automotive Gasolines: First, states should not be involved in the business of regulating the motor fuels business. Refiners, regardless of location, service a number of states. If states begin to implement differing fuel regulations, the refiner does not have storage and shipping capabilities to address this. This results in a decrease in the refiners distribution efficiency and resulting increases in product price. These price increases are not limited to the regulating areas but often affect other geographic areas as well.

Secondly, if the government wants the ethanol industry to survive, it must provide a 1.0 psi Reid Vapor Pressure (RVP) tolerance for ethanol blends. If and when ETBE develops as a commercial product such tolerance may become unneccessary. However such a change-over will require several years.

Ease of Regulations on Methanol Handling: This area requires detailed analysis beyond the scope of our firms involvement.

Research on Improved Engine Design: Governments involvement in this area should be as a fleet operator to provide in-use information on various vehicle technologies as they are developed. Additionally the government could provide grants to worthy research projects.

Vehicle Emissions Research: Clearly there is a significant degree of disagreement on the affect of different fuel components on the environment. In order to render decisions which adequately protect our environment, it will be necessary to engage in a variety of vehicle emissions research. Projects should include not only computer models but smog chamber tests and speciation studies to accurately determine each fuel constituents effect on air quality.

Retraining for Mechanics: Throughout automotive history the acceptance or rejection of a motor fuel or motor fuel ingredient has been affected by the auto mechanic. Programs to provide the auto service industry with information on new motor fuels will aid in consumer acceptance of these products.

Grants to State & Local Governments for Purchase of Alcohol Fuel/Alcohol Fuel Vehicle : As stated elsewhere in this submission, it is necessary for the government to be at the forefront in use of alternative fuel vehicle fleets to encourage not only development of technology but also acceptance of these new vehicles.

Education & Information Programs to Create a Favorable Image of Alcohol Fuels: Both from an industry and government standpoint, consumer acceptance of alternative fuels is a critical element of market growth. The alternative fuels industry is insufficiently financed to mount a massive nationwide consumer education program. Therefore if the government wishes to develop widespread acceptance of these fuels, an educational program is a must. Such a program should include all forms of media with special emphasis on radio and television public service announcements (PSA's)

Mandating Vehicle Production Quotas: Mandating the production of a certain type of vehicle should be discouraged. If public policy is correctly crafted to create the appropriate demand for these vehicles then industry will produce them in sufficient quantities. However in the early stages, governmental contracts could be structured so as to encourage production of such vehicles.

Encouraging Use of Methanol to Meet Clean Air & Emissions Standards: The CRS options assessment is valid. A great deal more information is needed to properly assess this topic.

Fuel Ethanol Monthly
May 1989

ETBE: Merit, Myths, & Misgivings (Part 1)

As we mentioned in our April issue the ETBE (ethyl tertiary butyl ether) movement continues to gain support. As is often the case with a new and promising product, one often focuses only on the positive attributes. *Fuel Ethanol Monthly* has, in the past, been chastised for taking a non-supportive position on ETBE. If by being pro-information we appear to be non-supportive, that is regretful. You try on a suit before you buy it, you test drive a car before you buy it, and ETBE is not all that much different. We believe ETBE does hold great promise for the industry, but we also believe that drawbacks need to be explored along with benefits. This multi- part article will attempt to provide that balance of information on the pros and cons which, we feel has been somewhat lacking from those who would apparently "by a suit without trying it on".

Need for Tax subsidy

Without question the commercial viability of ETBE is dependent upon qualification for the blenders credit. But since the ethanol that would serve as feedstock already receives the exemption, there is actually no loss in extending the credit to ETBE. In fact since the credit is taxable, it would result in less loss to the treasury. It would also come from the general funds, not the highway trust fund. This removes an entire group of opposition.

If imports circumventing legitimate tariffs are the issue, then Congress should fix that problem and get on with it. The credit won't cost the government any money, at least not in the near term.

Production Considerations

The technology exists and licensing agreements are available to construct ETBE plants. Construction costs have been shown (on a product yield basis) to be comparable to building a MTBE plant. Therefore it would appear that return on investment would be comparable to an MTBE plant (assuming the blenders tax credit is available). Still refiners will want to see projections on ROI, yield, feedstock cost projections, catalyst costs, and comparisons against MTBE.

Additional areas that still need to be clarified would include the cost of making the plant dual feedstock capable (ethanol/ETBE or methanol/MTBE). This is important because refiners building etherification plants would likely not select the ETBE process because it is dependent on a tax incentive which would change with the whims of congress.

By building the plant with dual capabilities, producers could switch back and forth between the most economically favorable process. Information on the cost and possibility of modifying existing MTBE plants to dual capacity is also needed. If such prospects are feasible it would allow for more rapid growth of ETBE when the time comes. Also oil companies considering ETBE projects will likely want to see economics on refinery integrated plants as well as stand alone facilities. Therefore a hypothetical scenario should be constructed on a model refinery to demonstrate cost effectiveness of ETBE in a refinery integrated operation.

Additionally there is some lack of clarity about the purity of feedstock required. Several people have the misperception that ETBE would be made from ethanol that is identical to that used for fuel blending. Such is not the case. ETBE feedstock would probably require removal of fusel oils which are typically present in fuel grade ethanol. This would require additional tankage at some products facilities, one for fuel grade, one for feedstock grade. Also since the ethanol would not be denatured, product would have to be shipped under bond and the ETBE production facility would be required to have a DSP.

Feedstock Availability & Considerations

Given the limited amount of capital available to construct plants and the uncertainty of making investments based on the continuation of an incentive, ETBE growth would likely be

— *(Coninued on page 21)*

ETBE...*(con't. from page 20)*

dependent, at least in part, on ethanol's ability to compete with methanol as a feedstock. Therefore it will be necessary to prepare a model scenario of worldwide demand for methanol and the effect that could result if a portion of the etherification market is lost to ethanol. No one knows better than the ethanol and petroleum industries how few gallons of long product it takes to drive down an entire market. It was not all that long ago that methanol was $.30 per gallon. At that time it would have hardly been the pricing mechanism of choice for the ethanol industry. The price of ethanol used for ETBE production would unquestionably be driven by the supply/demand pricing profile of methanol.

Aside from the competition at the feedstock level, there would be competition at the finished product level, ETBE versus MTBE, to think otherwise is sheer folly. Thus, to determine the viability of ETBE it is necessary to determine the total market for oxygenates in the U.S. motor pool. The cocktail napkin guestimates that have been bandied about are not justification for major capital investments.

A further area of concern is that of isobutylene supply. Will enough isobutylene be available for ETBE and MTBE production. This is dependent on a number of factors. It is widely accepted that isobutylene supply is limited. However with EPA's volatility rulemaking and even more stringent fuel volatility regs from Northeastern states, there will be an excess of butanes. This product could be dehydrogenated and isomerized to provide feedstock for ETBE and MTBE production. Therefore adequate co-feedstocks would likely be available but the additional processing adds expense to the product.

Logisitics

Determinations need to be made for plant locations, distribution, and storage. This necessitates determining where the product will be sold. Most advocates point to the Colonial Pipeline market (Eastern Seaboard) as the most promising. In this scenario, mid-western plants would have to rail product to the Gulf Coast for etherification and addition to gasoline for pipeline shipment. Once in the Gulf Coast area product could easily come back up the Explorer and TET pipelines thus eliminating oxygenate free base gasoline for ethanol blending.

Other options would include etherification at independent midwestern refineries or stand alone facilities.

ETBE as a Fuel Component

This is the area where ETBE shines the brightest. One of its greatest benefits is that it would be pipeline fungible. Water solubility is not expected to be a problem although there needs to be verification that fuel hazing would not be a problem. Pipeline fungibility would allow ETBE to penetrate markets that have been largely out of reach of the ethanol industry.

ETBE also provides octane benefits comparable to MTBE. Research Octane Number (RON) is 117-119 and Motor Octane Number (MON) is 99-104 providing an Anti-Knock Index (AKI) of 108-111.5. The lower octane sensitivity and high motor octane are perceived as a plus compared to ethanol. Additionally it is believed that Road Octane will test out higher than an ethanol blend. Also because of ETBE's boiling temperature (162 degrees F) it would provide good front end octane in carbureted vehicles.

The area of most interest to refiners, however, is ETBE's low Blending Reid Vapor Pressure (BRVP). The BRVP of ETBE is approximately 4 psi compared to 18 psi for ethanol and 8 psi for MTBE. Thus ETBE could be utilized in a refinery blend strategy to blend back butanes. As an example, starting with a 10 psi base fuel and adding 10% each of ETBE, ethanol, and MTBE would give an approximate RVP of 9.4 psi, 10.1 psi, and 9.8 psi respectively.

Also despite ETBE's low boiling point it forms azeotropes with the hydrocarbons in the gasoline and does not depress mid-range distillation characteristics as much as ethanol.

ETBE has a lower oxygen content than ethanol. Depending on your viewpoint, this could be a plus or a minus. Some argue that driveability is better at lower oxygen levels, while others want

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ETBE...*(con't. from page 21)*

to see higher oxygen levels for environmental reasons.

It is important to note that many of the numbers being used including those in this article are based on a limited data base. One of the things necessary for refiners to properly consider ETBE as a fuel component will be an empirical data base that analyses octane response, BRVP, and distillation curves across a variety of fuel formulations.

An empirical data base will also provide the proper foundation for an analysis of the economics of ETBE as a fuel component. Accurate calculations are needed to determine cost per octane barrel and other economic considerations. Such considerations would include the butane credit resulting from the refiner's ability to add more butane as a result of ETBE's lower BRVP. But this is not an easy area to assess. Vapor pressure is not the only consideration. The refiner must be sure that the distillation curve is not distorted and the octane is distributed across the full boiling range. You cannot have all the octane in the front end of the gallon. Another consideration for individual refiners will be the refinery run debit. If a refiner uses large quantities of ETBE to achieve octane, he must consider whether or not it results in a lower operating capacity for his unit. The affect of modifying either volume or processing also affects products other than gasoline.

Automotive Issues

ETBE as a fuel component must also be viewed from the automaker's perspective. Although the automakers are favorably inclined toward ETBE, their unqualified endorsement will require analysis and testing in the area of materials compatibility, deposit characteristics, and driveability. These tests are now beginning to take place and this information is crucial in gaining the support of the automakers.

CONTINUED NEXT MONTH

Oil Company net income up 27.8 percent but continues to trail non-oil companies

An American Petroleum Institute (API) survey reveals that a group of the 20 major oil companies, last year, experienced net income of $19.3 billion, an increase of 27.8 percent over 1987's net income of $15.1 billion. According to API, 1988 revenues for the group of oil companies was $360.9 billion, an increase of 4.2 percent.

The API noted that in 1988 the companies had near record earnings from petroleum refining and marketing operations and from chemical operations. Such "downstream" operations earned $8.9 billion—a 200 percent increase over 1987.

API noted however that the gain was partially offset by a sharp decline in exploration and production earnings which declined 36.5 percent from 1987.

API noted that 1988 profitability returned 13.9 percent in net income as a percent of shareholders equity compared to 11.1 percent in 1987.

API pointed out that despite the improved performance, the oil industry continues to experience lower rates of return than a group of 100 leading non-oil companies, who enjoyed an average 18.8 percent return for the same period.

The 20 oil companies surveyed were Amerada Hess, American Petrofina, Amoco, Ashland, Atlantic Richfield, BP America, Chevron, Diamond Shamrock R&M, Exxon, Kerr-McGee, Maxus Energy, Mobil, Murphy, Occidental, Pennzoil, Phillips, Shell, Sun, Texaco, and Unocal.

Congressman Alexander Appointed to U.S. Alternative Fuels Council

Congressman Bill Alexander (D-ARK) has been appointed as a congressional representative to the United States Alternative Fuels Council. The Council will work with the Inter-Agency Commission on Alternate Motor Vehicle Fuels to develop a comprehensive, national alternate fuels policy.

Both the Council and the Inter-Agency Commission were established by the Sharp-Rockefeller Alternative Motor Fuels Act of 1988. The Council will offer its proposals by 1992.

A reception honoring Congressman Alexander's appointment to the Council was held at the Cannon House Office Building, Washington D.C., on April 26, 1989.

ETBE: Merit, Myths, & Misgivings (part II)

This is part II of a two part article covering the benefits, drawbacks, and varying opinions about the use of ETBE (ethyl tertiary butyl ether).

Last month we covered many of the more apparent and frequently argued topics concerning ETBE. This month we continue with information on other technical considerations, market potential and public policy considerations.

Other Technical Considerations

In addition to the automotive considerations mentioned in last months issue, there are other technical and safety questions that will need to be answered. For instance an expanded look at materials compatibility will be necessary for neat handling and storage of ETBE. Determinations are needed on what toxicity issues will be important such as groundwater content limits considered to be safe. While these issues may not seem that important, they point out some of the various steps of bringing a new product such as ETBE into the marketplace.

Market Potential

Perhaps one of the areas that draws the most disagreement is trying to project the market potential for ETBE. First, it is difficult to even find a level of agreement on where the product would be sold. Several ETBE proponents believe ETBE would be targeted at the Eastern states where little ethanol is sold, thus providing new markets. The Colonial Pipeline which services these markets already moves large volumes of gasoline containing MTBE. However it is important to note that the Gulf Coast refiners that ship on the Colonial also ship on other lines. Therefore if ETBE is added at the refinery, it could easily be present in shipments to other areas because refiners may not all have adequate tankage to segment batches based on destination or pipeline carrier.

Actually it is more likely that as ethers become more and more generic, there will be no geographic distinction whatever. After all the purpose of the ETBE movement is to offer ethanol a market as a fungible octane component. Fungible octane components are used by refiners who derive economic benefit from their use, wherever that may be.

To offer accurate market projections it is necessary to identify the targeted customer. In this case, it is the refiner and that means a shift away from the independent blender who has been the mainstay of the ethanol industry's customer base. Several producers/resellers have expressed concern about leaving the independent high and dry to serve the refiner. They fear that if the petroleum industry changes position on ETBE that they could be left without a market.

If you boil things down to basics, there is unquestionably some market for ETBE. Perhaps the more important question to the ethanol industry is whether or not an ETBE program would result in increased ethanol production or a mere offset in a portion of the ethanol blending market.

A gallon of ETBE contains about 40% ethanol. Therefore each gallon of ETBE sold represents 0.4 gallons of ethanol. Projected octane response curves indicate peak octane economics at 8% or 9% concentration. The butane credit may push the blend ratio up to 12% or 13% before the gallon contains to much light end components.

If we assume that ETBE contains the ethanol equivalent of 0.4 gallons ethanol, enough ethanol capacity exists (1 billion gallons) to produce 2.5 billion gallons of ETBE. With the U.S. gasoline market pushing 120 billion gallons, a 12% blend ratio would require a 10% market penetration. Added to current MTBE market share, this results in a market penetration for oxygenates approaching 30%. This is exclusive of any growth that might be desired. Clearly whether or not this type of market penetration is realistic depends in large part on public policy considerations.

It is also important to note that for the ETBE industry to grow, they will be facing some significant competitive factors. The finished ether will have to compete against MTBE (both foreign & domestic). The processing plant will have to compete for isobutylene feedstock. Most importantly, ethanol will have to compete against methanol as the etherification feedstock. This is important because methanol prices have softened somewhat and could drop further in an economic slow-down. If methanol falls back into the $.40 per gallon range, it will be difficult to compete against as an etherification feedstock.

For those who believe that ETBE will grow in leaps and bounds, it is important to review the growth

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ETBE: ...(continued from page 11)

pattern of MTBE. In the past 10 years U.S. MTBE production has grown from nothing to over a billion gallons. Keep in mind that in the case of MTBE, the feedstock and finished products are controlled by the major oil companies. To assume that a product that is partially agriculturally derived could grow faster than one of the petroleum industry's own products is a bit over-optimistic. This is especially true when you consider that MTBE was not competing against another ether when it entered the market.

If ETBE development follows the pattern of MTBE, then it would take approximately 10 years to create enough market share to use 400 million gallons of ethanol. So while ETBE may be more marketable than ethanol, it may not result in significant industry growth.

Some have put forth the argument that established producers are anti-ETBE because they are trying to impede industry growth. We do not understand this reasoning. If ETBE will truly be beneficial to the industry, then it will benefit those large established producers. Existing plants have an advantage over new plants. That is a fact of life. The production costs are often lower and that will be the case whether the competition is for the blend market or the etherification feedstock market.

Public Policy Considerations

Last but certainly not least are the public policy considerations involved with an ETBE industry. First it is a given that without extension of the blenders credit to ETBE there can be no industry. Secondly because of the lead time in constructing plants, it would be necessary to extend both the blenders credit and the motor fuels excise tax exemption for several years. The blenders credit extension is necessary to allow for plant construction and sufficient time to develop the market. The excise tax exemption is necessary to keep the ethanol industry producing so that feedstock is available for etherification as the market develops.

Use of the blenders credit to encourage ETBE production has significant benefits. Aside from being sourced from the general fund rather than the highway trust fund, the credit is taxable resulting in slightly less loss to the treasury. Also it would spur new economic activity in the construction of ETBE plants and later the construction of ethanol plants.

But from a market share standpoint, other public policy decisions may be more significant. The trend in reducing gasoline vapor pressure favors the use of low RVP components such as ETBE. If additional oxygenated fuels mandates are implemented this too would increase the market share for ETBE. Also because of its high octane, ETBE can serve as a replacement for aromatics in the gasoline/octane pool.

One other area that is seldom discussed is the potential for ETBE as an export product. Recently a U.S. delegation visited Mexico City to assess that city's air pollution problems. The carbon monoxide (CO) levels in Mexico City could benefit greatly from an oxygenated fuels program. One way to ensure ETBE and ethanol growth is to develop a plan that allows for export.

Perhaps rather than a blenders credit on ETBE, a manufacturers credit makes more sense. Paid to the ETBE plant operator for production from domestic ethanol, a manufacturer's credit ($.24 per gallon of ETBE equates to $.60 per gallon of ethanol) would allow the product to be exported. It would also eliminate all the hassles of tracking the product and worrying about imports.

Summary

Our intention in presenting the various viewpoints and inter-related issues on ETBE was to try and put all of the information and arguments on the table and in perspective. We believe we have done that. We believe ETBE holds promise for the ethanol industry. It has many attributes as a fuel component. It is generally acceptable to the auto manufacturers. It would provide some market growth that might not otherwise occur and it provides an additional mode of survival to existing producers.

Public policy should be crafted to encourage the production of ETBE.

At the same time the hype needs to be laid aside and replaced with facts and accurate technical information so those in decision making positions (both government & industry) have the information they need to properly assess the ETBE option.

Senator ROCKEFELLER. I agree with you, Senator Daschle. And the fact that you and I both happen to be Democrats actually is not important because we got just as much help from the Republican side. Senator Danforth was a supporter back in 1985. Senator Wilson from California was a very strong supporter of all of this, and I just think it is one of those situations where various people from various points of view with various constituencies came together to understand that something had to happen.

And I never will forget our first conversation when we just came together and decided we were going to get rid of all this nonsense and work together for our common interests of both ethanol, methanol and all alternative fuels. I think that was a significant moment at least for me.

Senator DASCHLE. Well, and it was for me. And I think the results are going to become even more apparent as the months unfold.

Senator ROCKEFELLER. Thank you very, very much, Senator Daschle, for being here.

You used the word "special" investigation. Every time I hear that word these recent weeks, I get nervous. [Laughter.]

Senator DASCHLE. Your name hasn't come up yet.

Senator ROCKEFELLER. Okay.

Senator DASCHLE. Thank you.

Senator ROCKEFELLER. Thank you, Senator Daschle, very much.

Our next panel is Dr. Fred Bowditch, Vice President, Technical Affairs Division, Motor Vehicle Manufacturers Association, Dearborn, Michigan; Mr. Robert Yuhnke, Senior Advisor, Environmental Defense Fund, Boulder, Colorado; Mr. Dixon Smith, General Manager, Strategic Planning and Business Evaluation, Chevron USA, San Francisco, California; and Mr. Milton Back of Kanawha Valley Regional Transportation Authority, Charleston, West Virginia.

And perhaps, Mr. Smith, in that I picked on you just a bit, I ought to give you the chance to start.

STATEMENT OF DIXON SMITH, GENERAL MANAGER, STRATEGIC PLANNING AND BUSINESS EVALUATION, CHEVRON USA, INC.

Mr. SMITH. Well, thank you, Mr. Chairman, members of the subcommittee. My name is Dixon Smith. I am General Manager of Strategic Planning and Business Evaluation for Chevron USA.

Chevron appreciates Senator Ford's invitation to speak to you today. My oral comments will summarize my written testimony. As the Senator requested, I will focus on the future role of alternative fuels in the context of U.S. energy and environmental policy and on the role of the government in promoting utilization of alternative fuels.

Chevron USA is the largest supplier of transportation fuels in the United States. We are in the energy business in the broadest sense. We are not a skeptic of methanol or any other alternative fuel. We intend to continue to supply the transportation needs of our customers for the long haul, whether it is gasoline, methanol or other alternative fuels. We have the national resources, the petroleum, the natural gas, the oil shale, the coal, whatever is needed for the future, and we will be there in the future supplying the needs of the public.

Interest in alternative transportation fuels stems primarily from two national goals: reducing dependence on imported energy and reducing air pollution caused by motor vehicles.

In addressing alternative fuels, Congress should focus on these national goals. This will ensure that the strategies selected are consistent with these goals and that proper priorities are established. Alternative fuels represent just one of several means of achieving these goals, and alternative fuels vary widely in their potential to contribute. They are not a panacea in general.

Let me explain why I suggest a goal-oriented focus. I will discuss each of the two goals in turn.

The first goal of reducing dependence on imported energy will require rational strategies involving energy conservation combined with greater use of domestic energy resources. These strategies may or may not involve use of alternative fuels.

For example, the United States has an immense amount of crude oil in the ground which is not economically recoverable at the current time. Improved techniques for enhanced oil recovery have great potential to reduce crude oil imports. This does not involve alternative fuels.

Much longer term there are a variety of options for converting domestic coal into liquid transportation fuels.

Much of the alternative fuels focus is on methanol. Methanol can be made from either natural gas or coal. Unfortunately, it can be made at a much lower cost from natural gas, particularly in foreign countries which have more gas than they can use or economically ship to other countries. More than one-half of this surplus gas is in the Soviet Union. Excluding the USSR, over 80 percent of the remainder is in OPEC countries. Hence, use of methanol made from natural gas may contribute to energy diversity, but it is unlikely to reduce dependence on insecure sources of imported energy. And, of course, importing a finished fuel instead of crude oil as a raw material also adversely affects energy security, the balance of payments and domestic jobs.

Regarding the second national goal, alternative fuels can reduce air pollution caused by motor vehicles. Natural gas seems to have the greatest potential to reduce vehicle emissions in the near term. However, customer acceptance problems concerning vehicle range, safety and refueling will limit widespread use. The potential for methanol vehicles is currently unresolved. Uncertainties surrounding methanol exhaust composition and the ability to adequately control emissions in actual use must be clarified through further research.

All fuels require tailoring of the engine and its emission control system to optimize emissions performance. No fuel is inherently clean in the absence of such optimization. Improved emission control for vehicles using conventional fuels may be more feasible and less expensive than converting to alternative fuels before they are economic.

The goal is to reduce vehicular emissions, and this should be done by setting emission standards. This will allow the creative scientists and engineers in the private sector the necessary flexibility to find the optimal combination of fuel, engine and emission control technology.

Nothing could be more imprudent now than to choose and totally rely on a single method, one tactic, as the way to reduce vehicular pollution over the next 20 years. The California South Coast Air Quality Management District recognized this when they adopted their new air quality management plan. The plan calls for low emitting technology and extremely low emitting technology vehicles and does not specify any one particular fuel.

The effort to develop low emitting vehicles should encompass all promising fuels, including modified gasoline and diesel. Improved engine designs and emission control technologies should also be pursued. The best minds from industry, government and academia should be put to work and ample funds should be provided. Hard information would then be available to compare all fuel-vehicle systems and their effects on air quality.

Chevron and other major petroleum companies are prepared to fund and participate in a private-public sector cooperative effort to develop and demonstrate low emitting fuel-vehicle technologies.

I have sketched out a positive program to reduce air pollution due to automobiles, an action agenda for progress and accomplishment.

Before concluding, I must also address an unworkable concept. This is the concept of fuel mandates. Alternative fuel mandates are almost certain to be inefficient and may be unworkable. The costs are likely to be massive and unacceptable to the public. Even with solid consumer acceptance, a mandate could backfire and be rescinded promptly if unknown or improperly investigated health and safety issues lead to excessive health risk or environmental impacts. The resulting failure of the massive investments made by industry to accommodate such a mandate would have a disastrous effect on future alternative fuels to development.

If it can be demonstrated that the use of alternative fuel vehicles is cost effective in achieving air quality goals, the use of market incentives to subsidize the purchase of higher cost alternative fuels would be preferred to mandates.

What is Government's role? As a first step, Government should establish the vehicle emission standards required to achieve national air quality goals. This will allow vehicle manufacturers and fuel suppliers to develop cost effective solutions which meet air quality needs consistent with consumer acceptance.

There is a clear need for consensus building on the cost effectiveness of alternative fuels in achieving clean air goals. This subcommittee and the administration could help by encouraging the cooperative low emitting fuel-vehicle development program I have outlined.

Secondly, Government should assume a major role in well-designed fleet demonstrations of low emitting vehicle technologies. These demonstrations should include evaluations of emissions control system effectiveness and durability, fuel economy, maintenance and consumer acceptance. Government should also play an active role in initiating needed health effects and air quality impact studies.

To conclude, most petroleum companies have the potential to supply a wide variety of transportation fuels including methanol. Gasoline, methanol and other alternative fueled low emitting vehicles should be evaluated fully to resolve the major performance, economic, health, safety and environmental issues. Chevron and other companies are already working with government agencies and vehicle manufacturers to resolve some of these issues. These cooperative studies should be expanded.

Thank you.

[The prepared statement of Mr. Smith follows:]

WRITTEN STATEMENT OF

CHEVRON USA, INC.

BY DIXON SMITH

BEFORE THE UNITED STATES SENATE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

HEARING ON ALTERNATIVE MOTOR VEHICLE FUELS

JUNE 6, 1989

WASHINGTON, DC

INTRODUCTION

Mr. Chairman, members of the subcommittee, my name is Dixon Smith. I'm the manager of Strategic Planning and Business Evaluation for Chevron USA.

Chevron appreciates Senator Ford's request to speak to you today. As the Senator requested, I will focus my remarks primarily on the future role of alternative fuels in the context of U.S. energy and environmental policy, and on the role of the government in promoting the development and utilization of alternative fuels.

Chevron U.S.A. is the largest supplier of transportation fuels in the United States. We are in the energy business in the broadest sense and intend to continue supplying the transportation fuel needs of our customers for the long haul.

Chevron has invested over $300 million in R&D over the past decade in developing technology for making transportation fuels from oil shale, coal and natural gas. We have substantial domestic oil shale and coal resources which could be converted to gasoline and diesel fuel. We also have very large natural gas resources around the globe which could provide transportation fuels in the form of compressed natural gas (CNG), or be converted to methanol, gasoline or diesel fuel.

There are a variety of energy resources and fuels which may become economic on a widespread basis when crude oil prices increase substantially. Generally speaking, this will require a doubling or tripling of crude oil prices, which may occur by the 2025 to 2050 time frame. However, fuels such as liquified petroleum gases (LPG) or CNG may be economic sooner in niche markets such as centrally-fueled fleet applications. Chevron is the largest producer of natural gas and the largest wholesale marketer of LPG in the U.S.

Our street-corner retail outlets could be modified to sell methanol, CNG or additional LPG. We already have eight retail methanol outlets operating under a contract with the California Energy Commission to help refuel the demonstration fleet of methanol vehicles. LPG is sold at about 240 of our service stations in the U.S. Although we don't market CNG currently in the U.S., a Chevron affiliate is the largest marketer of CNG for vehicles in New Zealand. Chevron Canada also sells CNG at a few service stations.

FUTURE ROLE OF ALTERNATIVE FUEL SOURCES

As I interpret it, the interest in alternative transportation fuels stems primarily from two national goals:

1. reducing dependence on imported energy, and

2. reducing air pollution caused by motor vehicles.

Some alternative fuels have the potential to contribute to one or both of these goals. However, the potential of different alternative fuels varies greatly. Some have significant potential; others have little or none. Some may be significant in the next decade or two; others have longer term potential.

In addressing alternative fuels, Congress should focus on the national goals. This will assure that the strategies selected are consistent with these goals and that proper priorities are established. Alternative fuels represent just one of several means of achieving these goals. And, as I stated, alternative fuels vary widely in their potential to contribute. They are not a panacea in general.

Let me explain why I suggest a goal-oriented focus by discussing each of the two goals in turn.

REDUCING DEPENDENCE ON IMPORTED ENERGY

The rational strategies for achieving this goal involve energy conservation combined with greater use of domestic energy resources. These strategies may or may not involve use of alternative fuels.

For example, the U.S. has an immense amount of crude oil in the ground which is not economically recoverable at the current time. Improved techniques for enhanced oil recovery have great potential to reduce crude oil imports, and this does not involve an alternative fuel.

Much longer term, there are three major options for converting domestic coal into liquid transportation fuels:

1. making conventional gasoline and diesel fuel by direct liquefaction;
2. making conventional gasoline and diesel fuel by indirect (two-step) liquefaction; and
3. making methanol by a two-step process.

In addition to industry programs, the DOE has a $71 million R&D program for fiscal year 1989 on conversion of coal to liquids. Methanol from coal cannot compete with conventional fuels made by direct or indirect coal liquefaction unless it can be made at a lower plant gate cost which more than offsets the additional storage, distribution and vehicle costs due to the fact that methanol contains only about half as much energy per gallon.

The National Academy of Engineering has established the Committee on Production Technologies for Liquid Transportation Fuels at the request of DOE in response to a legislative requirement. This committee will be reporting to DOE by late September on these and other options for producing liquid fuels from domestic alternative energy resources.

Unfortunately, methanol can be made at a much lower cost from natural gas in foreign countries which have more gas than they can use or economically ship to other countries. As shown in the attached Table 1, more than half of this surplus exportable gas is in the Soviet Union. Excluding the USSR, over eighty percent of it is in OPEC countries. Hence, use of methanol made from natural gas may contribute to energy diversity, but it is unlikely to reduce dependence on insecure sources of imported energy. And, of course, importing a finished fuel instead of crude oil as a raw material also adversely affects both energy security and the balance of payments.

Methanol economics will be addressed in more detail later on.

REDUCING AIR POLLUTION CAUSED BY MOTOR VEHICLES

Alternative fuels can reduce air pollution caused by motor vehicles. Among the alternative fuels, natural gas seems to have the greatest potential to reduce vehicle emissions in the near-term (excluding electric vehicles powered by nuclear fusion or solar energy and exotic fuels such as hydrogen which require substantial technological breakthroughs if they are to become practical). However, customer acceptance problems concerning vehicle range, safety and refueling will limit widespread use. The potential for methanol vehicles is currently unresolved due to uncertainties surrounding exhaust composition and the ability to adequately control emissions in actual use by consumers.

A recent report, "Potential Emissions and Air Quality Effects of Alternative Fuels - Final Report" by Sierra Research compares emission control performance of gasoline and methanol vehicles. The attached Figure 1 from this report illustrates that the emission control performance of methanol vehicles is not as good as that being achieved with gasoline vehicles.

All fuels require tailoring of the engine and its emission control system to optimize emissions performance. No fuel is inherently clean in the absence of such optimization. Improved emission control for vehicles using conventional fuels may be more feasible and less expensive than converting to alternative fuels before they are economic.

If the goal is to reduce vehicular emissions, this should be done by setting emission standards. This will allow the creative scientists and engineers in the private sector the necessary flexibility to find the optimal combination of fuel, engine and emission control technology.

This approach is working for heavy duty engines where EPA has set progressively more stringent particulate and NOx emission limits. Detroit Diesel Corporation has announced that it will sell methanol engines to comply with the most stringent standards which will apply in 1991 to urban buses. The reason for this decision is that the required emission control technology for diesel engines (particulate traps) will not be commercially viable by 1991. When these more stringent standards go into effect for other heavy duty vehicles in 1994, particulate traps are expected to be available for use with diesel engines. Oil refiners have met with engine manufacturers and agreed to provide new low sulfur diesel fuels to help make the trap technology feasible. The market will decide which fuels are used at any point in time, depending on emission control technology, fuel costs and vehicle costs and performance. In 1994, it may be more attractive for transit fleets to buy diesel buses than to continue buying methanol buses. The customer will decide which fuels and vehicles will be sold. This is the most efficient approach to controlling vehicle emissions.

ECONOMICS OF NATURAL GAS-BASED METHANOL

Figure 2 compares the 1988 average price of methanol to the average price of gasoline for large bulk shipments on the U.S. Gulf Coast. To give the same vehicle mileage, methanol costs about twice as much as gasoline. Figure 3 shows that the current $0.60 per gallon price for methanol in barge quantities is just below the middle of the historic range.

The current global methanol manufacturing and shipping capacity of 7 billion gallons per year is minuscule compared to the 130 billion gallons per year U.S. transportation fuel market. About ninety new world scale methanol plants would be required to replace just California's share (approx. 11%) of the current U.S. consumption of gasoline and highway diesel fuel. With the associated new tankers, this would require a capital investment ranging from 40 to 70 billion dollars based on current technology, current port sizes and individual 2500 metric ton per day methanol plants. (This does not include the cost of developing additional natural gas fields and pipelines to provide feed and fuel for the methanol plants.)

Additional investments would be required for large new port facilities to receive methanol tankers. In addition, the onshore fuel distribution and marketing system would have to be doubled in size because methanol contains about half as much energy as gasoline and diesel fuel. This means twice the pipeline capacity, terminal and bulk plant storage, tank trucks with trailers and service station storage and pumping capacity.

Energy and Environmental Analysis, Inc., have estimated the capital investment which would be required for a fuel methanol infrastructure in the South Coast Air Basin in the year 2007. Based on a projected demand of 5.1 billion gallons per year of M85 and M100, EEA es~~timated an~~ investment of $1.4 billion (in 1988 dollars).

Chevron USA organized and managed a joint industry/government study to develop definitive cost estimates for building and operating natural gas-based methanol production facilities at selected sites around the world, and for transporting the methanol to Los Angeles. Other participants in this study included methanol producers, the California Energy Commission, the South Coast Air Quality Management District and the Electric Power Research Institute, as well as several other energy companies. This study was recently completed and presented to the California Advisory Board on Air Quality and Fuels. A copy of the Executive Summary is attached.

Chevron and some of the other participants commissioned Stanford Research Institute (SRI) to assess the overall economics of methanol. Drawing together the results of studies on future availability and costs of natural gas at the various sites, plant financing considerations and LA Basin distribution costs, SRI projects that, in 2007, the added costs to the consumer of owning and operating methanol-fueled vehicles will be: 30-45¢ per gallon gasoline equivalent for light-duty vehicles, and; 45-65¢ per gallon diesel fuel equivalent for heavy-duty vehicles.

ECONOMICS OF COAL-BASED METHANOL

Chevron estimates that methanol from coal would cost about $1.00-1.25 per gallon ($1.80-2.25 per gasoline equivalent gallon) using current technology and current methanol plant sizes (200 million gallons per year). This estimate assumes that the plants are built in the United States. This compares with a cost of $0.45-1.05 per gallon ($0.81-1.89 per gasoline equivalent gallon) for natural gas-based methanol produced in large-scale complexes (1,200 million gallons per year) and delivered to Los Angeles, as estimated in the above mentioned study. The cost for coal-based methanol could drop by $0.15 to $0.20 per gallon, as it did for natural gas-based methanol, if large-scale complexes are assumed.

The above estimates are in 1988 dollars and are based on economic assumptions typically used by major petroleum and chemical companies for evaluating projects. The largest cost component in each of these estimates is related to the capital cost. Consequently, reductions in the cost to build the plant could have a significant impact on the required selling price. This is the primary reason that large-scale complexes produce methanol for less. Feedstock costs are also significant. Therefore, process efficiency improvements would also lower the required selling price. However, thermodynamic considerations suggest that future efficiency improvements will be modest.

DOE LIQUID-PHASE METHANOL TECHNOLOGY

On the subject of the DOE liquid-phase methanol synthesis technology, we feel the LaPorte pilot plant test was a necessary step towards developing credible technical data on this process. However, further development is required to commercialize the process. One key element is to demonstrate the process on actual synthesis gas from a coal gasifier. The current plant is running on a prepared synthesis gas derived from natural gas. It has not been demonstrated that the catalyst can handle coal-derived synthesis gas on a regular basis, or that the catalyst can recover from upsets from a coal-based first stage.

We would also caution that the LaPorte technology may not be the major factor affecting the published methanol price reductions. The economics are based on combining power production (using coal gasification combined-cycle technology) and methanol production. The DOE is using "utility financing" for the entire plant although they suggest that the methanol may go into unregulated markets (e.g. transportation fuels). Allocation of costs and risk to the two products (power and methanol) is complex in these public/private partnerships and there are operating difficulties in these coproduction schemes that are glossed over in the economics.

We have not examined the LaPorte technology in detail, but question its ability to significantly reduce methanol costs when evaluated on a standalone basis. Methanol synthesis technology is relatively mature and significant cost reductions are difficult. Furthermore, most of the cost is associated with converting coal into synthesis gas, not with converting synthesis gas into methanol.

In any event, in view of the high cost of the first stage of a coal-based methanol plant, it is unlikely that such plants will be competitive with remote gas-based plants in the foreseeable future.

AIR QUALITY POTENTIAL OF ALTERNATIVE FUELS

Chevron's near term interest in alternative fuels is due to their potential to help reduce motor vehicle emissions. We are a California-based corporation with substantial business in Southern California, which has the nation's most severe ozone non-attainment problem by far. Chevron is committed to being part of the solution of that problem. We have cooperative programs with vehicle manufacturers and government agencies to evaluate the potential of alternative fuels. For example, our Chevron Research Emissions Laboratory in Richmond, California is being used to measure emissions and fuel economy of methanol cars, trucks and buses -- in cooperation with the California Energy Commission, the Air Resources Board, and the South Coast Air Quality Management District. We're all learning more about methanol, its potential and its problems.

Although CNG has some drawbacks, it appears to be superior to alcohols from an environmental standpoint, considering the absence of high aldehyde emissions, lack of fuel toxicity problems and reduced contribution to the "greenhouse effect". It is also likely to remain less expensive than alcohols. However, while CNG appears to have air quality advantages over methanol, there is even less information available about emissions from CNG vehicles. Similarly, more information is needed about emissions from vehicles using LPG, including propane and butane.

There are a wide variety of alternative fuels. I've mentioned methanol, CNG, propane and butane. Electric vehicles are another possibility. All of these alternatives have both advantages and disadvantages. An obvious disadvantage is that they increase the consumer cost of buying and operating motor vehicles. They also require advances in vehicle technology if they are to offer performance which is acceptable to consumers. There are also important environmental pros and cons. There is no panacea.

With regard to the air quality impacts of using methanol as a fuel, there are three general areas of ongoing concern:

1.) Level and durability of vehicle emissions control achievable, especially for formaldehyde;

2.) The quantity and kinds of true hydrocarbons (non-oxygenated chemical compounds) emitted; and

3.) Prediction of air quality impacts associated with large scale conversion to methanol vehicles.

A recent report by Sierra Research summarizes the available data on the emissions characteristics of methanol-fueled light- and heavy-duty vehicles, as well as data for other alternative fuels, and identifies key development needs. A key issue is the comparative emissions between gasoline and methanol vehicles. The Sierra Research report also assesses recent air quality modeling studies of methanol replacement and suggests further work for this area as well.

METHANOL VERSUS GASOLINE VEHICLE EMISSIONS

Excellent control of formaldehyde emissions is essential if methanol vehicles are to be used widely. Formaldehyde is highly reactive in forming ozone. However, testing by Ford, GM and Chevron Research has consistently shown that current generation, multi-fuel vehicles emit 30-40 mg/mile of formaldehyde when operating on 85% methanol fuel (M85). This is three to five times more than when the same vehicles operate with gasoline. Data for these multi-fuel vehicles are available only at up to about 25,000 miles of service, and formaldehyde emissions from methanol are expected to increase steadily as mileage accumulates, as other emissions do.

There are also unresolved questions about emissions of hydrocarbons and nitrogen oxides (NOx) from methanol vehicles. Ford has found that vehicles using 100% methanol fuel (M100) emit significant hydrocarbons, which contradicts previous assumptions that there would be no hydrocarbons. Also, as shown in Figure 1, results to date show that methanol vehicles are emitting much more NOx than gasoline vehicles.

Several photochemical modeling studies have been conducted to evaluate the effect on ozone of substituting methanol vehicles for gasoline vehicles. However, these studies have made assumptions about methanol vehicle emissions which have not been borne out in practice. These studies have assumed very low formaldehyde emissions, no increase of NOx emissions and/or no hydrocarbon emissions with M100. Methanol vehicles capable of meeting these expectations may or may not be developed someday. That's a speculative call, not a certainty.

One example will help to put these concerns into context. The recent Carnegie-mellon University (CMU) air quality modeling study assumed that methanol vehicles will control formaldehyde emissions at a level of 3 mg/mile, lower even than current gasoline vehicles. The California Air Resources Board recently adopted emission standards for future methanol vehicles which require formaldehyde to be controlled at a 15 mg/mile level for 50,000 miles. However, formaldehyde emissions from Ford and GM flexible fuel vehicles are typically in the 30 to 40 mg/mile range at half this mileage. The automakers have gone on record that they do not believe it is feasible to build exhaust catalysts which control formaldehyde at the 15 mg/mile level for 50,000 miles in actual customer service, much less the 3 mg/mile level assumed by CMU.

However, it is essential to continue trying to advance all alternative fuel vehicle technologies and solve the problems.

OTHER METHANOL VEHICLE ISSUES

There are numerous additional health, safety and environmental issues associated with use of methanol as a fuel. Over the last few months, seven days of workshops have been conducted in an effort to identify the critical issues and most pressing research needs. These workshops were sponsored by the Coordinating Research Council, the South Coast Air Quality Management District and the California Advisory Board on Air Quality and Fuels. The following sections summarize the diverse health, safety and environmental issues to be resolved concerning methanol fuel.

METHANOL VEHICLE HEALTH ISSUES - FORMALDEHYDE

Based on the very limited photochemical modeling work conducted so far -- and, in California, this is only for the South Coast Air Basin -- methanol spark-ignition vehicles have the potential to slightly reduce peak ozone concentration if formaldehyde exhaust emissions can be controlled to the same level as gasoline vehicles.

Current generation, multi-fuel methanol vehicles emit 30-40 mg/mile of formaldehyde when operating on methanol at low mileage. This is three to five times more than from the same vehicles when operating on gasoline. Data for these multi-fuel vehicles are available only at up to about 25,000 miles of service, but formaldehyde emissions from methanol are expected to increase steadily as mileage accumulates. Formaldehyde emissions from the older 1983 Ford Escorts, which can operate only on methanol, are from 40 to well over 100 mg/mile at 25,000 to 40,000 miles. This is much higher than expected from comparable gasoline vehicles.

In addition to being a very "hot" photochemical reactant, formaldehyde is toxic in its own right. EPA has listed it as a "probable human carcinogen" and completed a risk assessment. Formaldehyde is also undergoing a risk assessment by the California Department of Health Services as a "toxic air contaminant".

It is essential to evaluate the highest formaldehyde concentrations which may occur. Summer airshed model studies alone are not adequate. Peak formaldehyde concentrations need to be evaluated under winter conditions when formaldehyde emissions are higher due to the longer warmup time required for vehicles' catalysts to become effective. Poor ventilation and high exposure situations should also be examined -- for example, winter tunnel, parking garage and urban street canyon situations and high exposure occupations such as bridge toll collectors and parking garage workers.

Even under summer conditions and with undemonstrated, excellent formaldehyde control assumed, the Carnegie-Mellon study indicates that formaldehyde concentrations in downtown Los Angeles may be up to about six times greater than the highest benzene concentrations measured anywhere in the South Coast Air Basin in 1986; and the average formaldehyde concentration substantially exceeds the average benzene concentration. Even higher formaldehyde concentrations would be likely in the winter and if durable formaldehyde emission control technology doesn't pan out.

We recognize that gasoline is hardly a benign substance. The point is that it would be poor public policy to stimulate widespread use of a new substance without understanding the consequences.

METHANOL VEHICLE HEALTH ISSUES - METHANOL TOXICITY

Methanol itself is acutely toxic. There is serious concern about control of exposure to prevent poisoning of motorists and mechanics. Ingestion of less than one ounce -- for example by siphoning of fuel -- can cause permanent blindness. Methanol is also readily absorbed by the skin. This means poisoning, even blindness, may result from misuse of the fuel as a solvent or hand wash and from spilling methanol on a pant leg or skirt when refueling a car.

Although methanol's acute toxicity is well understood, there is a dearth of information about the effect of long term, chronic exposure to low concentrations in the atmosphere. This is a topic which requires investigation. Another unresolved issue is the so-called "cancer fog" effect. This involves the potential formation of secondary toxic pollutants such as dimethyl sulfate from water-phase reaction of methanol in fog or clouds.

The effects and proper handling of groundwater contaminated by methanol are unresolved. First, methanol's mild taste and odor would make it difficult to tell when groundwater has been contaminated. Second, a report by Cambridge Analytical Associates indicates that leakage of a tank containing methanol would contaminate a six-fold greater area at a concentration one hundred to one thousand times higher than occurs when a gasoline tank leaks. This report also warns that the contaminated groundwater would turn anaerobic and generate methane, creating a flammability hazard over a wide area.

METHANOL SAFETY ISSUES

One of the key safety issues associated with pure methanol (M100) is that it burns with an invisible flame and therefore could potentially cause extensive personal injury. Even where M85 (85% methanol and 15% gasoline) is used as a fuel, M100 will be stored and blended somewhere in the fuel distribution system. This hazard needs further study to develop reasonable safeguards and awareness by all of those involved with this fuel.

There are other major safety and flammability concerns associated with the bulk storage and dispensing of M85 and M100. For example, the vapor space above methanol (M100) in a storage tank, either in a bulk terminal or underground in a service station, will normally be in the flammable range at temperatures between about 40°F and 120°F. Even with M85, the vapor space above the liquid will normally be in the flammable range at temperatures up to +10°F. The vapor space above gasoline is not flammable at these storage temperatures. Due to this flammability problem, alcohols are typically stored either in tanks with floating covers or having an inert atmosphere. This has not yet been addressed satisfactorily, particularly for underground tanks in service stations where it is not practical to provide an internal floating cover or an inert atmosphere. Also fire and explosion hazards associated with the transportation of these fuels in barges, marine vessels and tank trucks have yet to be addressed adequately.

The risks to people and property posed by the existence of flammable vapor concentrations in the vapor space of bulk storage tanks, underground tanks in service stations, marketing vapor recovery systems, and in the fuel tanks of motor vehicles is a major concern to the fuels industry and to the fire service. Ignition of vapor by any means could rupture the tank or system and fully engulf it in flame. In the case of bulk storage tanks this should not be a major problem to solve, but no easy solution is yet apparent for vapor recovery systems, service station tanks, or motor vehicle tanks. Past experience tells us that ignition of the vapor space can occur by such things as repair activities or motor vehicle accidents involving a dispenser pump and vapor recovery piping.

As you can see, widespread use of methanol involves environmental, health and safety risks which are currently not well understood.

GREENHOUSE EFFECT

There is also a global issue concerning the "greenhouse effect" of relying on methanol as a fuel. The methanol fuel cycle increases carbon dioxide emissions compared to using gasoline from crude oil. The increase is about 10% if the methanol is made from natural gas, but increases to about 80% if the methanol is made from coal.

In describing methanol problems and unresolved issues, my objective has not been to downgrade methanol as a fuel. Of all alternative fuels, methanol has the greatest potential, and Chevron has major programs underway to explore that potential. The point is that it would be premature to select methanol as the "fuel of the future" now and exclude other paths to energy security and clean air. A major government commitment to methanol at this time could lead to a massive setback in alternative fuel programs.

A STRATEGY FOR CLEAN AIR

A strategy for reducing motor vehicle emissions is more likely to succeed if it stimulates the creative, problem-solving talents of the private sector, and recognizes that it is impossible to determine now the best way to reduce emissions in the future.

This means that government should set reasonable performance standards through the regulatory process and let the automotive and energy industries determine how best to meet them, consistent with satisfying consumers' needs for safe, reliable and economically acceptable vehicle performance. There may be multiple ways of meeting performance standards. None should be ruled out.

Performance standards allow flexibility to adapt to changing economic, political, technological and environmental conditions. For example, the global warming issue may lead to constraints on fuels and transportation systems. Also, no one can accurately predict future prices of crude oil, methanol or natural gas, or any other alternative fuel, let alone their price relationships and when, or if, they will compete with one another for general use as transportation fuels.

Nothing could be more imprudent than to choose now and totally rely on a single method, one tactic, as the way to reduce vehicular pollution over the next 20 years. The Board of the California South Coast Air Quality Management District made a start toward recognizing this on March 17 when they adopted their new air quality management plan. The adopted plan calls for "low-emitting technology" and "extremely low-emitting technology" vehicles and does not specify any one particular fuel.

IMPLEMENTING THE CLEAN AIR STRATEGY -- LOW-EMITTING VEHICLE/FUEL SYSTEMS

The "low-emitting technology" vehicles approach must necessarily be based on performance standards -- if you will, government goals on the reasonable and necessary end result in terms of emission limitations. This raises the substantial question of, "how is government to set those emissions limitations?"-- An extremely difficult and complex task to be sure. To set the objective, at least three factors must be considered:

1. The air chemistry aspects of the phenomenon

2. The state of and expectations for emissions control technology

3. The balancing of societal impacts

Given a stated objective and sufficient time, the creative scientists and engineers in the private sector will meet the target. Working together, the vehicle, fuel, catalyst and emission control industries should be able to find the least cost solutions which satisfy air quality needs consistent with consumer and voter acceptance. As I stated earlier, this approach is already underway for heavy-duty engines.

Chevron and other major petroleum companies are prepared to fund and participate in a private-public sector cooperative effort to develop and demonstrate low-emission vehicle technologies.

All promising fuels, engine designs and emission control technologies should be pursued. The best minds from industry, government and academia should be put to work and ample funds should be provided. Hard information would then be available to compare all fuel/vehicle systems with regard to speciated exhaust and other emissions and emission photochemical reactivities. Air quality modeling using these data could be performed to evaluate all the options, singularly and in combination.

This program would offer valuable synergisms. For example, technology advances needed to reduce formaldehyde emissions from methanol-fueled vehicles are likely to further reduce hydrocarbons emitted by gasoline vehicles. Also common to all fuels and vehicle designs is the challenge of sustaining good emission control performance in actual use.

FUEL MANDATES WON'T WORK

I've sketched out a positive clean air strategy -- an action agenda for progress and accomplishment. Before concluding, I must also address an unworkable concept. That is the concept of fuel mandates.

Alternative fuel mandates are almost certain to be inefficient and unworkable. The costs are likely to be massive and unacceptable to the public.

Petroleum companies have had active alternative fuels programs over many years. From a resource standpoint, they have included exploration and acquisition of domestic coal and oil shale reserves, as well as natural gas in remote locations around the globe. From the standpoint of technology, they have invested billions of dollars in research, development and demonstration projects directed at finding more economic ways to provide transportation fuels from these resources. This includes making gasoline, diesel fuel, CNG, LPG, and methanol from these diverse alternative energy resources.

These alternative energy R&D commitments have been substantial, even though the fully developed alternative fuels era is probably at least two or three decades away. The commitments also have been diverse because it's too early to foretell with certainty which alternative fuels might be economic in the 21st century. It would be foolish for any broad-based energy company, or the nation, to put all of its eggs in any one alternative energy basket.

The major problem with fuels from alternative energy resources are that they cost a lot more than fuels produced from crude oil. Someday they may be competitive -- when crude oil is in short supply and more expensive. However, Chevron believes that this will not occur until well after the turn of the century -- perhaps toward the middle of the 21st century -- as depicted in Figure 4. There is still an awful lot of crude oil remaining in the world.

If it can be determined that the use of alternative-fueled vehicles is cost-effective in reaching air quality goals, the use of tax incentives to subsidize the purchase of higher cost alternative fuels would be preferred to mandates. Nonetheless, the private sector would undertake this massive investment program only if investors believed that methanol vehicles and fuel will receive long term public acceptance. This means that the vehicles must perform satisfactorily in all respects, the fuel cost must eventually be competitive and the public health consequences must be understood.

Even with solid consumer acceptance, a mandate or incentive could backfire and be rescinded promptly if unknown or improperly investigated health and safety issues lead to excessive health risks or environmental impacts. All of these factors would make it very risky for the private sector to rely on government mandates or incentives to create a market. What government invokes it can revoke.

The real problem at the heart of the so-called methanol "chicken and egg" issue is the cost of methanol. Methanol will be supplied for fuel use when and if it is economic to do so. The flexible, or variable, fuel technology assures this -- especially with the added bonus of CAFE credits for auto companies which sell methanol vehicles. If the chicken and egg impediment were a real issue, we wouldn't have seen:

o radios and television sets sold due to the paucity of broadcasting stations,

o CD players sold due to lack of CD's, or,

o diesel passenger vehicles introduced due to lack of convenient refueling locations.

Nevertheless, methanol vehicles do have the potential to help reduce vehicular pollution and should be included as part of the program I have recommended to develop and demonstrate low-emitting technology vehicles. It will also be necessary to more thoroughly evaluate the risk of adverse public health effects caused by increased chronic exposure to methanol, formaldehyde and their atmospheric reaction products.

GOVERNMENT'S ROLE

Well designed fleet demonstrations of alternative-fueled vehicles are a critical step toward enhancing the understanding and development of low-emitting vehicle technology. These demonstrations should include periodic evaluations of vehicle emissions to enable assessment of emissions control system durability, as well as rigorous recordkeeping on fuel economy and maintenance.

Government can certainly play a role here. The California Air Resources Board's recent adoption of emissions standards for methanol-fueled vehicles is a good example. DOE and other government agencies can help by collecting data from demonstration programs in their own fleets, as well as private fleet programs. Government should also play an active role in initiating needed health effects and air quality impact studies.

Fuel producers, automakers, vehicle operators and the government are understandably reluctant to make the investments required to develop a nationwide (or even a regional) alternative fuel market. This is due to the high costs, the uncertain health and environmental impacts and the question as to whether the benefits clearly outweigh the costs at this time.

This subcommittee and the Administration could help by encouraging consensus-building among the interested parties. Chevron initiated the California Fuel Methanol Cost Study to do just this. The broad-based sponsorship of this study helped to assure credible information on methanol plant and shipping costs.

However, stronger government support may be counterproductive unless there is consensus that alternative fuels are cost-effective in achieving clean air goals. Otherwise, the market will grow dependent on government subsidies or other market distortions which could become intolerable and be revoked. The bulk of the evidence suggests that fuel methanol, for instance, will not be economic for at least twenty years. Consequently, government attempts to commercialize fuel methanol now may result in a collapse of the market in the future when supports are removed.

CONCLUSIONS

To conclude, most petroleum companies have the potential to supply a wide variety of transportation fuels, including methanol. Methanol has considerable potential as a vehicle fuel and may become economic when crude oil prices have doubled or tripled.

Methanol vehicles and fuel should be evaluated fully to resolve the major performance, economic, health, safety and environmental issues. Chevron and other companies are already working with the California Air Resources Board, other government agencies and vehicle manufacturers to resolve some of these issues. These cooperative studies should be expanded. This would help pave the way for successful use of methanol as a vehicle fuel.

From the standpoint of converting domestic coal into liquid transportation fuels, there are two major options:

1) Making conventional gasoline and diesel fuel by coal liquefaction and

2) making methanol via a 2-step process.

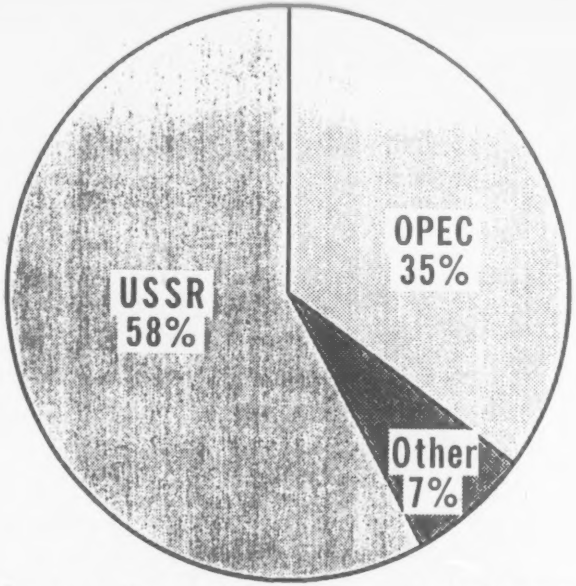
Methanol can compete only if it can be made at a lower plant gate cost which more than offsets the additional storage, distribution and vehicle costs due to the fact that methanol contains only about half as much energy per gallon versus gasoline and diesel fuel made by coal liquefaction.

The best way to reduce emissions from motor vehicles is to set reasonable emission standards and enforce them. This will allow vehicle manufacturers and fuel suppliers develop cost-effective solutions which meet air quality needs consistent with consumer acceptance. Air quality control measures will work only if consumers and voters buy into them.

Thank you. I will be glad to try to answer your questions.

TABLE 1

Exportable Surplus Natural Gas Reserves Are Highly Concentrated in the USSR and OPEC Countries

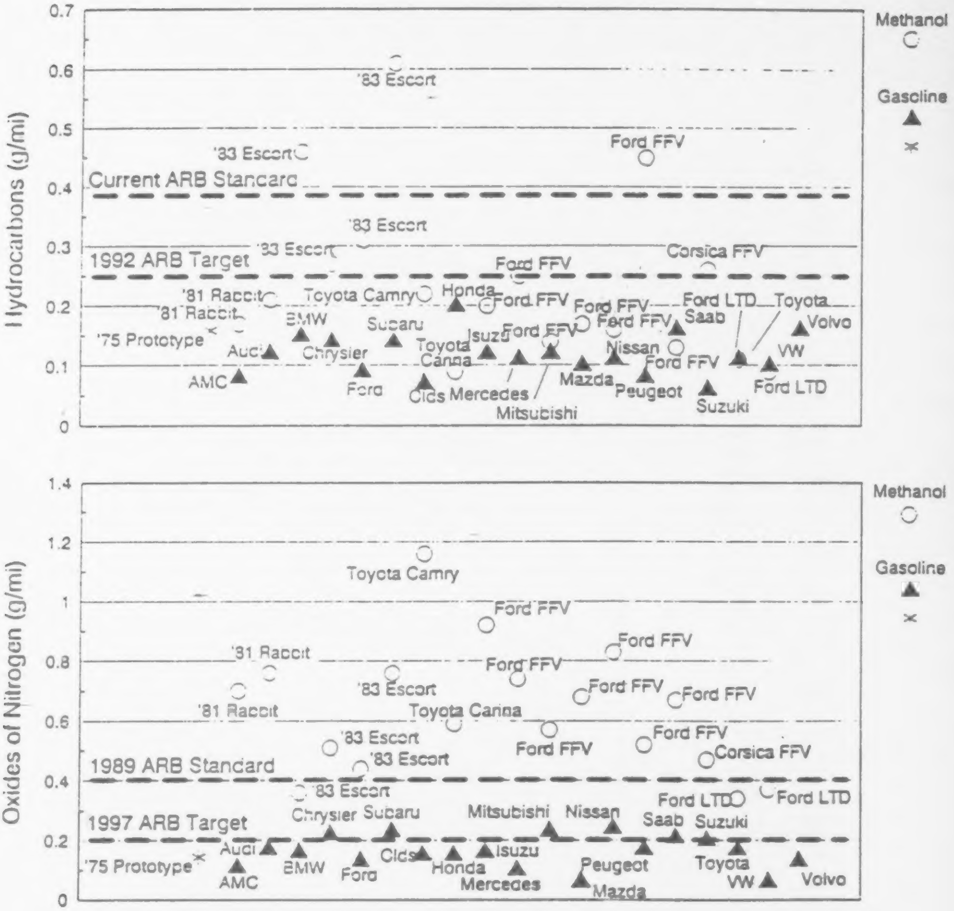


Source: Jensen Associates, O&GJ, 6/6/88

Country	TCF
USSR	763
Qatar	147
Iran	142
Abu Dhabi	60
Africa OPEC	67
Other OPEC	35
Other Non-OPEC	96
Total World Excl. USA & W. Europe	1310

FIGURE 1

A Comparison of
Gasoline and Methanol Vehicle Emissions
of Oxides of Nitrogen and Hydrocarbons



Notes : Methanol vehicle emissions data are best ARB test results after catalyst stabilization (generally 4,000 miles). Gasoline vehicle emissions are 50,000 mile certification values.

Methanol vehicle emissions are based on Organic Material Hydrocarbon Equivalent "OMHCE" technique recommended by EPA. Gasoline vehicle emissions are NMHC.

FIGURE 2

Comparison of Methanol and Gasoline Prices
U.S. Gulf Coast 1988 Avg.

$/Gallon

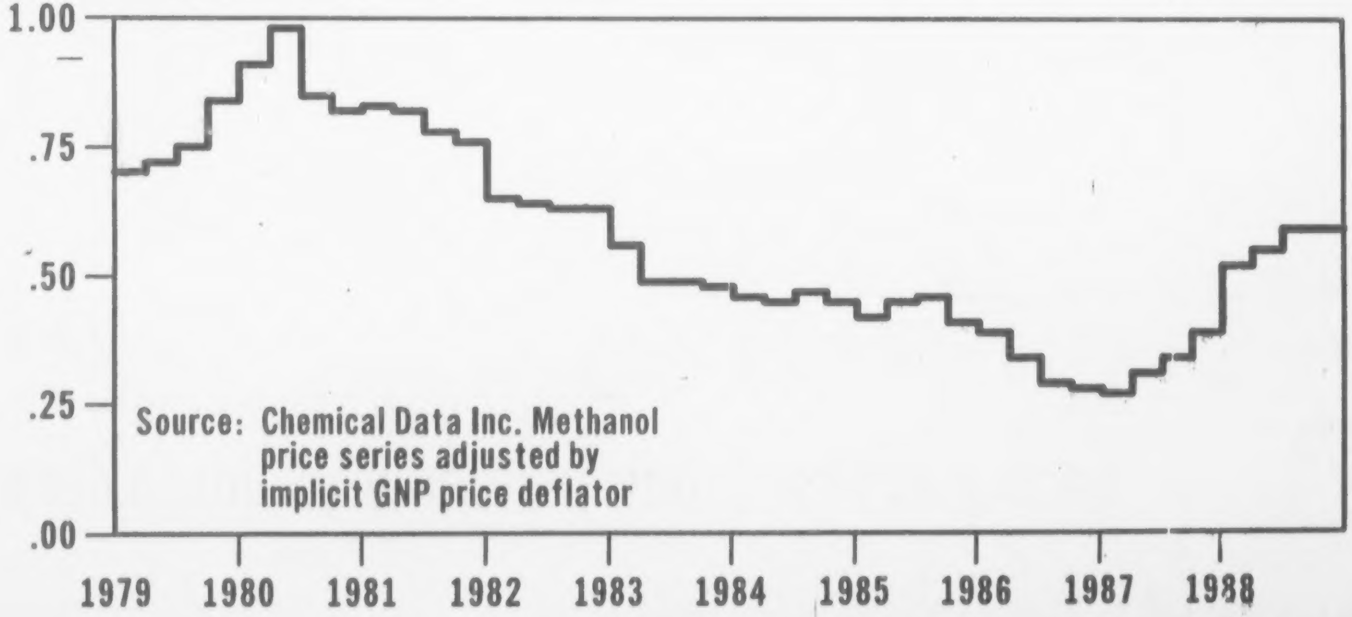
● Regular Unleaded Gasoline Cargoes	0.47
● Methanol Barges	0.56 as methanol 1.00 mileage-equivalent, based on 1.8 gallons methanol per gallon gasoline

- Methanol barge prices are 2 times more expensive than gasoline cargoes even on U.S. Gulf Coast where methanol is a large commodity chemical
- Methanol costs more in California

FIGURE 3

Quarterly Average Methanol Prices U.S. Gulf Coast Contract Barges

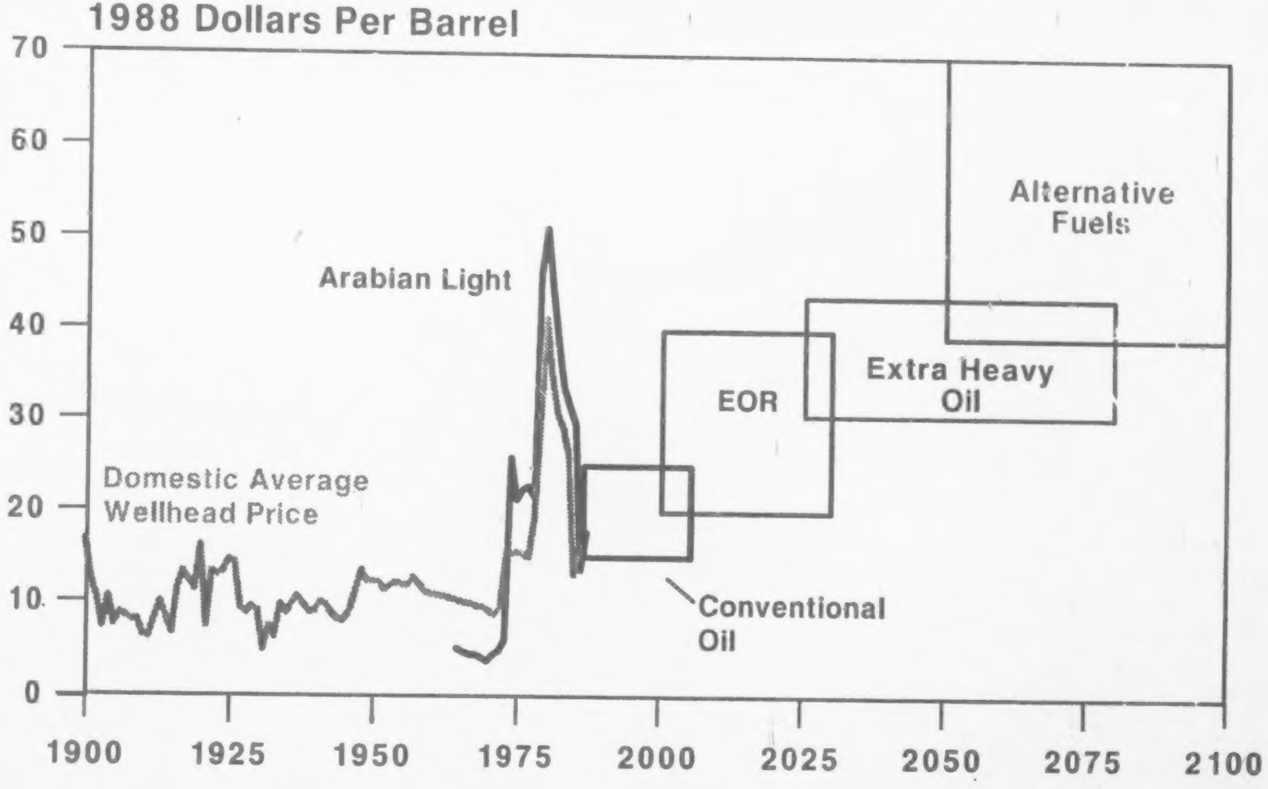
1988 $/ Gallon



Source: Chemical Data Inc. Methanol price series adjusted by implicit GNP price deflator

FIGURE 4

Crude Price Outlook



Executive Summary
Volume I

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Study Origins

Significant interest has recently been expressed nationwide concerning the use of methanol as an alternative motor fuel to gasoline and diesel. Several state legislatures and local governing bodies have passed, or are considering, legislation to encourage the use of methanol. Methanol will most likely be produced from natural gas, and, therefore, offers the potential to diversify and expand the energy resource base. This is particularly true for motor fuels, which are largely derived from crude oil. Furthermore, methanol fuel may offer the potential to improve air quality by reducing vehicle and stationary source emissions.

In 1987, the California Energy Commission sponsored the Methanol Plant Investment Roundtable. At the Roundtable, it became apparent that more definitive information was needed to determine the investment required to establish natural gas-based methanol plants, both within the United States and at various gas producing regions around the world. Consequently, a program was developed to evaluate costs for six representative sites. Bechtel, Inc. was chosen through a competitive process to carry out the study. The study also determines the cost to transport the methanol from the study sites to Los Angeles, California. Los Angeles was chosen because its air quality management district has adopted a policy of replacing petroleum-based fuels with cleaner fuels such as methanol.

The cost information in this study is necessary to help establish informed energy and environmental policy. Ten organizations sponsored the study to provide information to assist legislators and regulators in evaluating the potential merits of methanol. These sponsors, who represent a broad cross section of affected interests, are:

- Chevron U.S.A., Inc. (managing sponsor)
- Amoco Oil Company
- ARCO Products Company
- California Energy Commission
- Canadian Oxygenated Fuels Association
- Electric Power Research Institute
- Mobil Research and Development Corporation
- South Coast Air Quality Management District
- Texaco Refining and Marketing Inc.
- Union Oil Company of California

Bechtel, Inc. supplemented its own resources with resources from the sponsors. Process packages were also supplied by three leading methanol technology licensors.

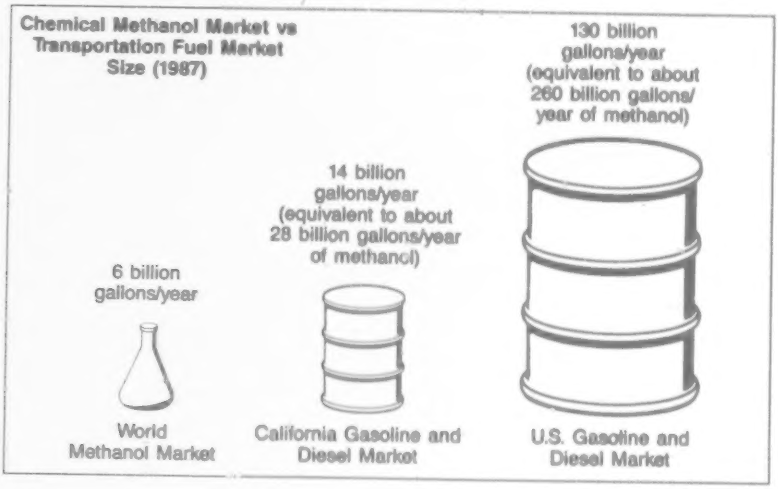
Study Assumptions

The Market

The study assumes that a substantial methanol fuel market exists, and that very large methanol production facilities can be built to serve this market. The methanol facility capacity for this study is 10,000 metric tons per day. This facility would produce 1.2 billion gallons (U.S. gallons) per year of methanol. This is more than four times the capacity of the current largest plant. While this represents a significant amount when compared to current chemical methanol production (6 billion gallons per year), it is only a small percentage of the gasoline and diesel market that it would impact. Fuel methanol production from this facility would be equivalent to about 4 percent of the combined California gasoline and diesel fuel market, and only 0.5 percent of the U.S. market.

The methanol facility size used for this study captures most of the economies of scale; in particular, those associated with:

- Using the maximum size plant within the limits of conventional technology
- Using a single plant design for several identical plants
- Purchasing several identical pieces of equipment
- Sharing support (offplot) facilities
- Maintaining a stable, skilled construction workforce



Chemical Methanol Market vs Transportation Fuel Market Size (1987)

Study Assumptions (Cont'd)

Transportation Costs

To derive transportation costs, this study assumes that the methanol fuel market would be concentrated in the Los Angeles area because of the region's interest in using methanol fuel as a component of its air quality improvement plan. It also assumes that the methanol will arrive either by tanker or dedicated pipeline.

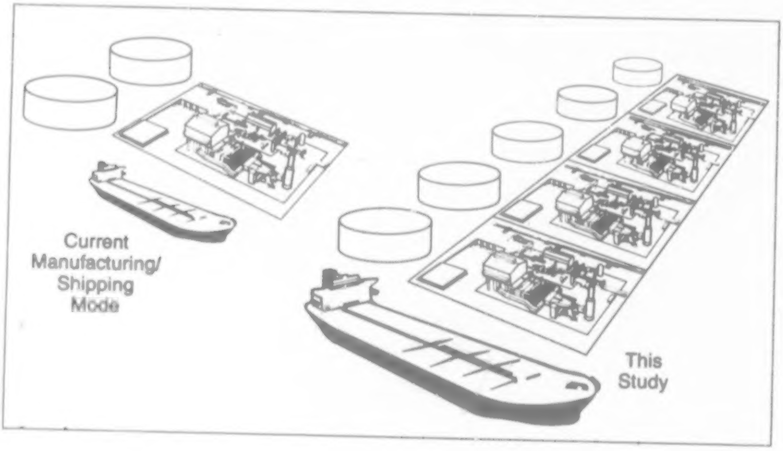
The study examines a range of tanker sizes, up to the maximum size as limited by either water depth at the ports or, in some cases, the size of the Panama Canal. Pipelines were also considered either in conjunction with tankers or as an alternative transportation method. Pipeline capacity was set equal to the output of the facility.

Fuel Sales Costs

The cost of methanol fuel sold at the service station is the sum of many component costs. These include the costs of:

- Natural gas for methanol plant feed and fuel
- Methanol manufacturing
- Methanol transportation
- Local distribution and marketing
- Local sales taxes and fuel excise taxes

The study focuses on manufacturing and transportation costs. It does not include other costs that would need to be added to determine the price at the pump.



Study Assumptions (Cont'd)

Investment and Operating Costs

The sponsors agreed that the study would only report the investment and operating costs. The study does not report the total cents per gallon cost, since this cost is sensitive to financial and economic conditions which vary significantly from location to location and by the mode of ownership. Determination of the appropriate financial and economic conditions is outside the scope of this work.

The cost of the methanol facilities was determined using a factored cost estimating technique. A factored estimate breaks the cost into several major components which can be individually adjusted. This allows the estimate to be scope-, site-, and time-specific.

The costs generated in the study include all the costs that a plant owner would incur in building the facility, including purchase and transportation of the equipment and construction materials to the jobsite, field construction, licensor charges for the process design, upfront licensor royalty charges for use of the process, contractor's cost, owner costs, and the cost of spare parts.

Many studies do not include all of these costs. For example, a contractor will typically quote costs to the client that exclude licensor fees, royalties, and owner costs. A contractor's quote may also be restricted to just the facilities directly associated with producing methanol (onplot) and exclude essential support (offplot) facilities. The investment costs in this study are two to three times the direct onplot field costs.

Study Configuration

The study examines both commercially proven conventional technology and emerging technology, and focuses on six natural gas supply regions.

Technologies Studied

The study develops investment and operating costs for:

- **Conventional Technology.** Investment and operating costs are developed for manufacturing fuel grade (99.5 percent) methanol using conventional reforming technology at six natural gas producing regions around the world. Costs are also developed for transporting the methanol from these six regions to the Los Angeles area.
- **Emerging Technology.** The study estimates the potential cost reduction that could result from using three different emerging methanol process technologies: combined reforming, catalytic partial oxidation, and fluidized-bed methanol synthesis.

Study Configuration (Cont'd)

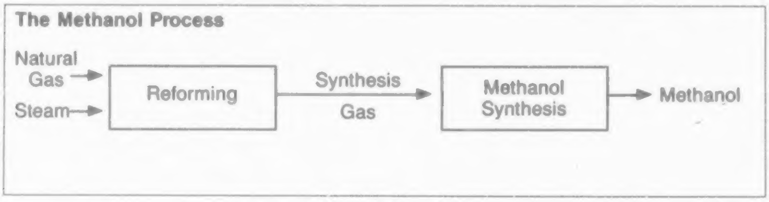
Study Regions

The study focuses on six major natural gas supply regions in the world. Each region could potentially supply all of Southern California's fuel methanol needs. For each region, a specific site location was selected as representative of construction costs for the region. Each of the sites has sufficient natural gas resources to support the natural gas needs for the size of methanol facility being considered. The regions and sites are:

- The U.S. Gulf Coast—Port Arthur, Texas
- South America and the Caribbean—Point Lisas, Trinidad
- The Middle East—Jubail, Saudi Arabia
- Australia and the Far East—Dampier, Australia
- Western Canada—Edmonton, Alberta
- The Arctic—Prudhoe Bay, Alaska

Conventional Technology

Methanol manufacturing is a two-step process. In the first step, natural gas is converted into synthesis gas, which consists of hydrogen, carbon oxides, steam, and unconverted natural gas. In the second step, the synthesis gas is converted into methanol.



The Methanol Process

Steam-methane reforming technology is used for the first step, and conventional methanol synthesis technology is used for the second step. These technologies are available from many process licensors. Conventional technology is currently limited in output to about 2,500 metric tons per day (300 million gallons per year) of methanol from a single plant, so four parallel plants (trains) are needed to produce 10,000 metric tons per day (1.2 billion gallons per year).

Conventional Technology (Cont'd)

The major facility parameters used for this study are shown in Table 1. The methanol facility is designed to be self-sufficient with regard to steam. Excess steam is used to generate power for the facility. Any excess power is sold to the local power company at current buyback rates.

The total natural gas required (feedstock and supplemental fuel) is the same for each site, about 110 billion cubic feet per year. All plant sites use a methane-rich (over 95 percent) natural gas with a 1,030 Btu per standard cubic-foot (higher-heating value [HHV]).

Table 1 Facility Parameters

Item	Parameter
Plant Capacity (all sites)	10,000 metric tons per day; four trains at 2,500 Mtd each
Product Specification (all sites)	99.5 volume % methanol
Natural Gas Required (all sites)	110 billion standard cubic feet per year (1,030 Btu per standard cubic feet, HHV)
Product Shipment	
Port Arthur	50,000 dwt(1) tankers; new wharf
Point Lisas	35,000 dwt tankers; new wharf
Jubail	120,000 dwt tankers; existing wharf
Dampier	90,000 dwt tankers; new wharf
Edmonton	Pipeline to Vancouver; 35,000 dwt tankers from Vancouver; existing wharf
Prudhoe Bay	Pipeline to Valdez; 120,000 dwt tankers from Valdez; existing wharf
Project Design and Construction Period	
Port Arthur	62 months
Point Lisas	62 months
Jubail	74 months
Dampier	65 months
Edmonton	62 months
Prudhoe Bay	74 months

Note:

(1) One deadweight ton (dwt) is equal to about 335 gallons of methanol

Conventional Technology (Cont'd)

Investment Costs

Total investment costs were determined at each of the six sites (see Table 2). These costs include the direct field costs, indirect field costs, other field costs, engineering and home office costs, owner costs, and contingency. These costs are shown in mid-1988 constant dollars. The investment costs were derived by using 1988 vendor quotes for equipment, prevailing freight rates, today's labor costs, etc. The aggregated cost is called a mid-1988 constant dollar cost.

Direct Field Costs. These include costs of equipment and materials and their installation costs. These costs have been determined for both the methanol plants (onplot) and support (offplot) facilities. Major direct cost components include:

- **Major equipment.** These include pumps, heat exchangers, vessels, furnaces, reactors, etc. Process equipment was sized and construction materials were specified based on the process packages. Major equipment was priced based on budget quotes from vendors and on in-house pricing.

  For Port Arthur, more than 90 percent of the major equipment cost was based on equipment quotes from vendors. Major equipment for the offplots was also priced by budget quotes or in-house data.
- **Bulk materials.** These include piping, instrumentation, concrete, etc. Bulk material costs were determined as a percentage of the major equipment and were based on historical data to build similar types of facilities.
- **Direct labor.** Direct labor is labor involved in the installation of equipment and materials. Manhour requirements were based on historical data for similar plants. Costs were determined by applying site-specific labor rates and labor productivity factors based on the likely makeup of the construction workforce at each site.

Indirect Field Costs. These include costs that cannot be directly allocated to a specific task. Contractor indirects include unallocated labor, nonmanual labor, temporary facilities, construction equipment, and supplies. Contractor indirects are correlated as a percentage of direct labor and vary with location.

Other Field Costs. These include sales taxes, initial catalyst and chemicals, ocean freight, and import duties.

Engineering and Home Office Costs. These costs are incurred by the contractor or licensor(s) for engineering, procurement, and fees. Contractor home office costs and fees were calculated as a percentage of the field costs based on historical data. Licensor costs were given by the individual licensors.

Owner Costs. These are paid directly by the organization that has hired the contractor to build the plant. They are therefore not included by the contractor when preparing the facility estimate, and are usually estimated by the owner and added to the contractor's costs. They include: environmental review; land and right-of-way acquisitions; project insurance; and company personnel performing design and construction overview and project management. Owner costs include startup and operator training.

Conventional Technology (Cont'd)

Contingency. Contingency is added to the estimate to cover scope omission, inaccurate cost data, construction problems (such as unforeseen weather problems), schedule slippage due to late deliveries by vendors, and unforeseen permitting problems. It is not an allowance for inflation. The contingency was determined by a risk analysis technique that uses a Monte Carlo method to predict the probability of overruns and underruns on each major cost area of the estimate. The contingency selected for each site corresponds to a 50 percent probability of a cost overrun. In other words, it is the most likely cost since there is an equal probability of a cost overrun and a cost underrun.

Operating Costs

Operating costs are those costs incurred to operate the methanol facility. These include utility costs, such as electric power and water; operating labor and supplies, such as catalyst and chemicals; maintenance materials and supplies; and taxes, insurance, and corporate overhead. Some operating costs such as taxes and insurance are fixed, while others vary with the annual production rate. Natural gas used for feedstock and fuel is an operating expense; however, by spons~~or agreement, it h~~as been separated out since a determination of gas prices was not part of this study.

Table 2 Conventional Technology: 10,000 Mtd Methanol Plant Investment and Operating Costs

(in U.S. $ millions, mid-1988)

Investment Cost	Port Arthur	Point Lisas	Jubail	Dampier	Edmonton	Prudhoe Bay
Direct field cost						
Onplot	416	414	436	536	475	545
Offplot	137	184	141	264	112	157
Indirect field cost	52	74	70	216	87	172
Other field costs	46	41	114	78	30	131
Engineering, home office, fee	64	71	71	98	58	89
Owner costs	46	58	74	89	35	105
Contingency	122	143	182	256	128	299
Total	883	985	1,088	1,537	925	1,498
Annual Operating Costs (excluding natural gas)						
Fixed operating costs	57	61	66	98	58	101
Variable operating costs	7	7	16	7	4	9
Total	64	68	82	105	62	110

Conventional Technology (Cont'd)

U.S. Gulf Coast (Port Arthur, Texas)

The Port Arthur location is typical of the Texas/Louisiana coastal area. This area has numerous refineries and petrochemical plants. There are many local equipment fabricators and construction firms, and the local workforce is skilled and familiar with heavy plant construction. The land is flat, and, while pilings are required to support the heavy equipment, the climate does not require special winterization of the plant.

The investment cost is lower for Port Arthur than for the other sites considered because of the combination of favorable construction conditions, local availability of competitively priced equipment, and extensive existing infrastructure.

The extensive electric grid in the area provides backup power and a ready outlet for excess power generated by the plant. The need for spare parts and spare catalyst is also minimized because of local availability.

South America and the Caribbean (Point Lisas, Trinidad)

Trinidad also has a refining and petrochemical industry, though not as extensive as that on the U.S. Gulf Coast. The local workforce is generally skilled and familiar with heavy construction, but it relies more on imported equipment and foreign construction firms for design and procurement. Expatriate labor is also used for certain specialized jobs. The Trinidad site is level and near the harbor. Since most of the major equipment must be imported, ocean freight costs are incurred. Proximity to the fabrication industry on the U.S. Gulf Coast, however, keeps these costs manageable.

The methanol facility uses seawater cooling instead of cooling tower water because of the limited availability of fresh water. This accounts in a large part for the difference in cost between this site and the U.S. Gulf Coast site.

The study assumes that import duties would be waived for imported equipment used on this project. This is the typical practice in Trinidad for a project of this size. However, if import duties are not waived, the capital cost would increase by about 4 percent.

Middle East (Jubail, Saudi Arabia)

Jubail is a modern industrial center in Saudi Arabia, and a terminus for the large national gas gathering system. There is access to existing support facilities, including a modern deepwater wharf, a seawater supply system for cooling, and a desalinated water supply.

In spite of these favorable conditions, development at Jubail is limited by the scarcity of local labor and the absence of local equipment fabricators. The construction labor force must be largely brought in from other countries, such as Korea, the Philippines, and Malaysia, where labor costs are low. More specialized skills will be provided by expatriates from Europe, America, and Japan. Construction camps will be needed, and housing will have to be built for the permanent workforce.

Australia and the Far East (Dampier, Australia)

Large gas resources are located off the northwest coast of Australia. This area is rocky and very sparsely populated. Dampier (population 3,000) was chosen as the plant site because some infrastructure has already been established by a large liquefied natural gas project being built there.

Costs for a plant at Dampier are considerably more than for the U.S. Gulf Coast plant, because of the need for extensive additional infrastructure and the requirement to maximize the Australian content of the project. The national labor unions are strong, and the construction labor rates are very high. About a third of the process equipment will come from Australian fabricators, located largely in the southeastern corner of Australia. Imported equipment is taxed with a 17 percent duty.

Western Canada (Edmonton, Alberta)

Alberta has a mature refining and petrochemical industry. The workforce is skilled and familiar with heavy construction. A significant portion of the necessary equipment could be built in Canada.

The cost to establish a plant at Edmonton is higher than for the U.S. Gulf Coast primarily because of the size of the project relative to the local workforce. A project of this size will require the use of union labor in Alberta, whereas the U.S. Gulf Coast plant can be built with open shop labor. The Canadian plant will also require special winterization to keep plant reliability high. These cost increases are partly offset by the inland location, which reduces the product tankage requirement and eliminates the need for a wharf. Less tankage is needed since the product will be shipped by pipeline, whereas tankers are used to move the U.S. Gulf Coast product.

Arctic (Prudhoe Bay, Alaska)

The harsh Arctic climate requires the use of specialized construction techniques. Most equipment is housed in large modules that are built at staging areas in Washington or Oregon. These modules are barged to Prudhoe Bay during a short ice-free period in late summer. The modules are off-loaded, set on refrigerated foundations, and connected during the fall. This construction technique is expensive, but less costly than field construction at the site. Tankage requirements are reduced because the product will be shipped by pipeline to Valdez, Alaska.

Transportation

Alternative transportation modes were examined for each of the six sites. Primary transportation is expected to be by tanker or pipeline, or a combination of the two. Given the large volumes being studied, railcar transport is not competitive, although rail facilities for shipment of modest amounts of methanol are included for the Port Arthur and Edmonton sites to handle any local demand.

Conventional Technology (Cont'd)

The smallest tanker size examined was 35,000 deadweight tons (dwt), which is about 10 million gallons. The largest size considered was 250,000 dwt, which is about 80 million gallons. This size is typical of the very large crude carriers used to transport crude oil. The largest size actually used is 120,000 dwt as limited by water depth at Los Angeles/Long Beach harbor. Overall transportation costs (including the investment and operating costs of the methanol plant product tanks, the shipping wharf, and the tankers) tended to drop with increasing tanker size. Incremental cost reductions with tanker size were greatest when moving from the small tankers to the medium sizes (around 100,000 dwt); use of much larger tankers does not reduce the transportation cost significantly.

The pipeline design rate was fixed at 10,000 metric tons per day. A pipe diameter of 14 inches was used for all pipelines after examination of the total transportation cost for a range of pipe diameters and pump stations.

More than one transportation mode is possible for some locations. For example, methanol can be shipped from Port Arthur by tanker or by a new pipeline. When multiple options existed, both transportation modes were evaluated. The most economic mode is reported in Table 3. Current Federal Energy Regulatory Commission (FERC) regulations were used to determine pipeline transportation costs; typical rates of return were used for determining tanker transportation costs.

Table 3 Transportation Costs: 10,000 Mtd Methanol

(in U.S. $ millions, mid-1988)[1]

Marine Costs	Port Arthur	Point Lisas	Jubail	Dampier	Edmonton	Prudhoe Bay
Investment cost	540	237	270	230	74	209
Annual operating cost[2]	34	27	24	19	6	9
Pipeline Costs						
Investment cost	—	—	—	—	300	2,500
Annual operating cost[2]	—	—	—	—	6	91
Total Transportation Costs						
Investment cost	540	237	270	230	374	2,709
Annual operating cost[2]	34	27	24	19	12	100
Calculated total transportation cost (in cents per gallon)	9	5	5	4	8	52

Notes:

(1) Except as noted

(2) Includes delivery delay costs

Conventional Technology (Cont'd)

As mentioned, both tankers and pipeline were considered for moving methanol from Port Arthur. The tanker size was limited to 50,000 dwt by the Panama Canal and the water depth of the Port Arthur channel. Moving methanol by tanker turned out to be less expensive than moving methanol by pipeline. The cost to move methanol by tanker from Port Arthur, however, is higher than moving it from Trinidad. This is in spite of the fact that shipping distances are similar and Trinidad is limited to smaller (35,000 dwt) tankers because of shallower water depths at Point Lisas. This seeming disparity is because of the Jones Act, which requires shipment between U.S. ports to be carried in vessels built in U.S. shipyards, and operated with U.S. crews under the U.S. flag. Methanol can be moved from Trinidad in foreign-flagged vessels which are considerably less expensive to build and operate.

The impact of tanker size is most pronounced for Jubail and Dampier. The water depth at the existing Jubail wharf is sufficient to handle 250,000 dwt tankers. The channel depth at Dampier is sufficient to handle 90,000 dwt tankers. The water depth at the Los Angeles/Long Beach harbor limits tanker size to 120,000 dwt. Methanol transportation costs for Jubail and Dampier are the lowest for all cases, even though these sites are the farthest from Los Angeles.

Two transportation options were considered for Edmonton. One option is to build a new pipeline from Edmonton to the eastern outskirts of Los Angeles (Colton). This pipeline would parallel the existing Alberta Natural Gas and Pacific Gas Transmission pipelines for most of the way. A scoping design and cost estimate was prepared for this option. Operating costs were also estimated assuming that expanded workforces would operate both the methanol pipeline and the adjacent natural gas pipelines.

The second option is a new methanol pipeline from Edmonton to Vancouver, British Columbia. This pipeline would parallel the existing Transmountain Pipeline. Tankers would then move the methanol from Vancouver to the Los Angeles/Long Beach harbor. Tanker size was limited to 35,000 dwt by the channel depth at Vancouver. This combination pipeline/tanker option is the more economic for moving the design volume of 10,000 metric tons per day. The all-pipeline route would be more economic if the design volume were greater.

Methanol can only be moved by pipeline from Prudhoe Bay because this site is icebound most of the year. The study assumed that a new pipeline would be required, and that it would parallel the Trans-Alaska Pipeline System which moves North Slope crude oil to the ice-free port of Valdez on the southern coast of Alaska. This pipeline would be very expensive because of the harsh construction climate. The estimated cost of this pipeline is $2.5 billion (mid-1988 dollars) based on recent experience with Alaskan pipeline construction. Large tankers could then be used to move the methanol to Los Angeles/Long Beach. The Jones Act would require the use of U.S. flag tankers.

The cost estimate for the Prudhoe Bay to Valdez pipeline is less accurate than that for the more intensively studied Canada-to-California pipeline. No further refinement of the cost was justified, however, since the cost is so high that Prudhoe Bay is not likely to compete with the other sites.

Conventional Technology (Cont'd)

Batch shipping in the Trans-Alaska Pipeline System was also considered but rejected, since it is not known if and when spare capacity will be available for methanol. The pipeline transportation cost would then include the pipeline tariff, which is currently 12 to 14 cents per gallon; costs for methanol and crude oil storage at Prudhoe Bay; and additional storage and separation equipment costs at Valdez to clean up the methanol-hydrocarbon mixture generated by the batching operation.

Emerging Technology

The study also looks at three technologies that could reasonably be assumed to be available for commercialization within the next several years. These are:

- Combined reforming from Lurgi
- Catalytic partial oxidation from Davy McKee
- Fluidized-bed methanol synthesis from Mitsubishi Gas Chemical

The combined reforming process has already been demonstrated on a commercial scale at Sabah, Malaysia, and Pasadena, Texas. The other two processes are in advanced stages of development.

It should be noted that this study is not a process selection study. The three processes were not extensively optimized and were not compared at all sites. Further optimization or local site conditions could change their relative attractiveness. Also, there are several even less-developed technologies that were not considered in this study since they are in very early stages of development and would not allow cost estimates to be made on a comparable basis.

Each of the emerging technologies uses oxygen from an air separation plant. The use of oxygen reduces the size of some of the key equipment, which permits larger train sizes. Each of the licensors provided process packages, which were used to establish the offplots and to develop cost estimates.

The major facility parameters for these three emerging technologies are:

- Plant capacity (all technologies): 10,000 metric tons per day; three trains at 3,333 Mtd each
- Product specification: 99.5 volume percent methanol
- Plant site: Port Arthur, Texas
- Natural gas requirement:
  - Combined reforming: 103 billion standard cubic feet per year
  - Catalytic partial oxidation: 108 billion standard cubic feet per year
  - Fluidized-bed methanol synthesis: 101 billion standard cubic feet per year
- Product shipment (all technologies): 50,000 dwt tankers; new wharf
- Project design and construction (all technologies): 56-month period

Emerging Technology (Cont'd)

Combined Reforming

The combined reforming process differs from conventional technology by adding an autothermal reformer after the steam-methane reformer. The steam-methane reformer is smaller since it processes only part of the feed gas and runs at milder conditions. The synthesis gas from the smaller reformer is sent to the autothermal reformer with the balance of the feed gas, where the gases react with oxygen.

The methanol synthesis stage is more efficient because the synthesis gas produced by combined reforming has less inert material and a better balance between the methanol reactants (hydrogen and carbon oxides).

Catalytic Partial Oxidation

The catalytic partial oxidation process differs from conventional technology by replacing the steam-methane reformer with a reactor that contains a catalyst. The feed gas, oxygen, and steam react in this vessel to produce synthesis gas. Catalytic partial oxidation, like combined reforming, produces a synthesis gas that contains less inert material and a better balance among the reactants.

The catalytic partial oxidation process also uses a different methanol synthesis technology. A tube-cooled converter is used to convert the synthesis gas to methanol.

Fluidized-Bed Methanol Synthesis

The fluidized-bed methanol synthesis process uses the same first stage as the combined reforming process. However, it uses a different methanol synthesis stage. The fluidized-bed methanol synthesis reactor uses a fine catalyst that is suspended as a dense cloud within the reactor by the reactants during operation. This allows for more efficient heat removal and a higher conversion than the other processes. The other processes use larger-sized catalyst that remains in place during operation.

Costs

Investment and operating costs were developed for the three technologies, and are shown in Table 4. The investment costs for all three emerging technologies are somewhat lower than for conventional technology. Two of the technologies show moderate reductions in natural gas consumption.

These processes have not been extensively optimized like conventional technology, and, consequently, additional cost savings are possible. However, it is also possible that further development will uncover areas where additional equipment is needed.

Contingency

Contingencies have been calculated using the same method as for conventional technology and are somewhat higher because of the lower level of confidence in the process information. New technology frequently encounters delays in startup, or has lower operating factors until fully developed at the commercial level.

Table 4 Emerging Technology: 10,000 Mtd Methanol Plant Investment and Operating Costs (U.S. Gulf Coast Location)

(in U.S. $ millions, mid-1988)

Investment Cost	Conventional Technology[1]	Combined Reforming	Catalytic Partial Oxidation	Fluidized-Bed
Direct field cost				
Onplot	416	358	337	381
Offplot	137	131	135	133
Indirect field cost	52	38	33	39
Other field costs	46	35	35	33
Engineering, home office, fee	64	57	57	58
Owner costs	46	41	41	41
Contingency	122	113	128	138
Total	883	773	766	823
Annual Operating Costs (excluding natural gas)				
Fixed operating costs	57	52	51	54
Variable operating costs	7	13	13	15
Total	64	65	64	69

Note:

(1) Conventional technology costs shown for comparison

Senator ROCKEFELLER. Thank you very much, Mr. Smith.
Mr. Yuhnke?

STATEMENT OF ROBERT E. YUHNKE, SENIOR ATTORNEY, ENVIRONMENTAL DEFENSE FUND

Mr. YUHNKE. Thank you, Senator. I appreciate your effort to investigate all sides of this issue because I think the question of whether or not the Nation is going to shift its fuels infrastructure is critical in a number of respects, not the least of which is the potential for environmental improvement.

It is clear that new initiatives are needed to protect human health in the urban environment. Alternatives to both diesel and gasoline may play an important role in providing these new initiatives. Diesel emissions today are the largest single source of environmentally induced lung cancer. Diesel emissions contribute a major percentage of ozone causing nitrogen oxide emissions. They also are a major source of the brown cloud in many cities, particularly those in the west.

Gasoline production, fueling and combustion is virtually the entire source of benzene in the human environment. The South Coast Air District and the California Air Resources Board estimate that between 100 and 1,000 leukemia deaths in the south coast basin occur every year as a result of benzene concentrations. It could well be that benzene, although we do not have comparable data for the rest of the country, may well account for half of the leukemia deaths in the United States, some 17,000 a year.

Gasoline combustion contributes 40 to 60 percent of the ozone precursor pollutants in the United States. And gasoline-fueled vehicles emit 70 to 80 percent of carbon monoxide in the urban environment. Alternatives to the current fleet of vehicles and the level of emissions from these vehicles are clearly needed especially in view of the trends in those emissions.

Diesel emissions are continuing to increase year after year. The new EPA standards for particulates and nitrogen oxides from diesels that cut in for buses in 1991 and for trucks in 1994 are not expected to reverse those trends but simply to slow them. We are not going to be making net improvements in overall emissions, simply slowing down the deterioration of diesel emissions.

The downward trend that we have seen for the last 20 years in gasoline-fueled vehicle emissions is expected to reverse. We have already seen a reversal in ozone concentrations in the eastern United States, a serious deterioration since 1986, and EPA is projecting that within the next 5 years, the total trends for tailpipe emissions of the other criteria pollutants, nitrogen oxides, particulates and carbon monoxide, will reverse for the first time in 20 years. Urban air quality can then be expected to begin to deteriorate instead of continuing to improve unless new strategies are adopted to reduce vehicle emissions.

Once again, alternative fuels do offer help in addressing these trends. Both CNG and methanol as alternatives to both diesels and gasoline offer some promise of reduced emissions of criteria pollutants.

The limited amount of research, however, that has been done on emission performance demonstrates mixed results. For diesels, for example, emissions of the two regulated pollutants, nitrogen oxides and particulates, demonstrates substantial improvement when methanol is burned or CNG is burned in the place of diesel oil.

However, for methanol, the emissions of carbon monoxide and hydrocarbons are substantially worse than with burning diesel, and with CNG there may well be a NO_x penalty compared to burning diesel. For autos methanol has demonstrated an improvement in hydrocarbon emissions, but it is not clear that we will not also experience perhaps some NO_x penalty and a formaldehyde increase in emissions.

For CNG-fueled autos, the data suggests that we can achieve a very dramatic improvement in carbon monoxide emissions, but there may be a NO_x penalty.

Now, as I say, these data are preliminary. These are the first test results. These are not the results that have emerged after years of effort to refine these technologies. We are hopeful that more can be done and that the adverse impacts on some pollutants can be eliminated so that we can achieve real benefits from those pollutants for which these fuels offer dramatic improved performance.

But these results also suggest that there is a strong need for additional research and development before we can be sure of the overall benefits from these fuels in terms of environmental impacts.

In addition, Senator, we think it is extremely important that as we think about the possibility of shifting fuels in this Nation, that we look at the potential greenhouse impacts of those fuels. Both CNG and methanol offer the possibility of contributing to increased emissions of the two most important greenhouse gases, carbon dioxide and methane.

For example, a major shift in production of methanol that would be derived from coal is expected to contribute a CO_2 penalty of anywhere from 30 to 50 percent compared to CO_2 emissions from the current gasoline fuel cycle. However, if methanol were made from natural gas, which virtually all of it is today in the United States, if it continued to be made from natural gas, then it appears that there might be a 5 to 10 percent benefit for CO_2 emissions from methanol. So, it is important to keep in mind what the entire fuel cycle would contribute in terms of these emissions.

For CNG the question is whether or not the obvious reductions in CO_2 emissions that come from burning a hydrogenated fuel, such as methane, natural gas, in place of gasoline would be offset by increased emissions to the atmosphere of methane which itself is a greenhouse gas. This tradeoff question needs to be much better researched. We need to understand these consequences before we make a long-term commitment to these fuels.

In our recommendations to the committee, the Environmental Defense Fund joins the key recommendations that have been made both by Chuck Imbrecht and Chevron here today, that Congress create a level playing field between all fuels and that evaluation of these fuels be based solely on performance. We do not think it is appropriate at this time to mandate specific fuel uses, particularly in view of the lack of adequate data to fully understand both the pluses and the minuses of these fuels.

In addition, we think it is extremely important that Congress direct EPA to include greenhouse gases as factors in comparing these fuels. Right now EPA is only comparing fuels on the basis of the regulated pollutants. For example, with regard to diesel, they are looking at the nitrogen oxides and the particulates which are the two pollutants for which they have standards for diesel oil. When you compare methanol against diesel on that basis alone, you see dramatic improvements.

But that should not be enough because the bus tests, the six buses that have been tested in New York City show that there is a potential 50 percent energy penalty in switching from diesel to methanol. Now, if that can be eliminated by improvements in design, that's fine. But if it can't, it seems to us that paying a 50 percent energy penalty which would have significant greenhouse gas emission consequences would not be an acceptable outcome.

So, it is important that Congress make clear to EPA that the criteria pollutants now used for evaluating performance are not the only criteria and that greenhouse gases should be included in the list of criteria for evaluating these fuels.

Thirdly, we strongly recommend that fuels be evaluated across the board with regard to all of the major pollutants in the urban environment that contribute to an adverse impact on human health, and that includes benzene which is not now a pollutant that EPA regulates or pays much attention to despite the fact, as Tom Daschle indicated earlier, it is an extreme cause of concern from the standpoint of human health in the urban environment. That should be added to the criteria for measurement. The nitrogen oxides and particulates that EPA already looks at for diesels, the carbon monoxide and hydrocarbons that EPA already looks at for gasoline, but in addition there should be added to that formaldehyde so that we are evaluating all of these fuels by the same set of criteria.

Finally, our bottom line recommendation is that in order to try to drive the kind of research and development that I think we have all recognized is important to give us the answers to these as yet unanswered questions, Congress should set in motion a national competition between fuels for the 1990s that would be driven by setting tighter tailpipe standards for both trucks and buses that are commonly fueled by diesels and for vehicles that are today commonly fueled by gasoline, standards that would be set to come into effect in 1998, and that those standards would then drive the kind of research and development across the board both by the manufacturers of the vehicles to identify the best on-board control technology and research by the fuels industries to identify the optimal mix, what is the best combination of fuels and on-board technology that will give us the improvement in the urban environment that we all seek and that will not exacerbate our impact on global warming.

Thank you, Senator.

[The prepared statement of Mr. Yuhnke follows:]

BEFORE THE SENATE

COMMITTEE ON ENERGY AND NATURAL RESOURCES,

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

STATEMENT OF THE ENVIRONMENTAL DEFENSE FUND ON THE DEVELOPMENT OF ALTERNATIVE FUELS

Prepared by Robert E. Yuhnke
Senior Attorney
Presented June 6, 1989

AN ACCEPTABLE URBAN ENVIRONMENT REQUIRES CLEANER VEHICLES. ALTERNATIVE FUELS OFFER THE POTENTIAL FOR SUBSTANTIALLY CLEANER VEHICLES, BUT POLICIES NEED TO BE CAREFULLY CRAFTED TO ENSURE THOSE POTENTIAL BENEFITS ARE REALIZED.

Air pollution in American cities undermines the quality of urban life by compromising the ability of large numbers of Americans to lead normal, productive and healthy lives. For some, pollution contributes to premature death or incapacitating disease. For others, it detracts from the enjoyment of the sweet smells of Spring, the experience of stars in the night sky, or the delight of distant mountain views. However we are affected, urban air pollution detracts from the potential offered by a clean and healthful urban environment.

Urban air pollution today is a by-product of a transportation system that relies primarily on the internal combustion engine. Since most Americans seem destined to spend their lives in the urban environment, it is essential that we continue to make progress in improving the emission performance of vehicles to avoid the disease, pain and discomfort caused by pollution. The grey-brown pall that shrouds major cities like New York, Los Angeles, Houston, Chicago, Denver, Phoenix, Albuquerque and Salt Lake need not be the curse of urban civilization, or the legacy of future generations.

Transportation sources account for 40% to 80% of air pollution in most American cities, depending on the pollutant.

The most common pollutants to foul the urban air are ozone (O3), carbon monoxide (CO), and particulates that include a wide array of contaminants ranging from respiratory irritants to potent carcinogens. Almost all of these pollutants can be traced to the emissions from gasoline and diesel-powered vehicles.

The severity of urban pollution levels is directly related to 1) the number of vehicle miles traveled each day, 2) the use and effectiveness of pollution controls on vehicles, and 3) the emission performance of fuels burned. As our cities continue to grow and vehicle use continues to increase, the impact of transportation sources on urban pollution can be reduced only if Congress requires the use of less polluting vehicles and fuels, along with transportation policies aimed at meeting mobility needs while reducing the use of single occupant vehicles.

The dramatic deterioration of urban air quality in the U.S. during the last two years has focused renewed public attention on the need for action. The number of ozone violation days in the U.S. (outside of California) increased from about 380 in 1986, the cleanest year in the last 15, to over 1250 in 1988. In 1988, urban ozone concentrations returned to pollution levels not seen in nearly a decade. Some major cities exceeded the health standard on more than 30 days, and approached the peak levels previously seen only in Los Angeles.

Based on EPA projections, pollution levels will increase even more in the next decade as tailpipe emissions begin to climb again for the first time in 20 years. The gradual, but impressive gains in urban air quality achieved since the passage of the Clean Air Act in 1970, will continue to erode if new initiatives are not taken to build on the progress of the past. Action is needed to assure a safe and healthy air supply for urban Americans.

For vehicle-related pollutants other than ozone, peak pollution levels today are less than one-third of what they were in many polluted cities during the early 70's, and the number of days when pollution levels violate national health standards have dropped by as much as 90% in many of the nation's more severely polluted cities. Despite this progress, most of the severely polluted cities of the 70's continue to have unacceptably high levels. Most important, the emission control programs adopted since 1970 are not expected to provide further reductions in total tailpipe emissions in the years ahead. After 1994, U.S. EPA projects that total vehicle emissions will begin to increase again for the first time since 1970.

Most of the tailpipe-related emission reductions since 1970 have come from Congressionally mandated tailpipe standards that have required automakers to produce cleaner cars. Total pollution reductions have come from replacing older, dirtier cars with new vehicles that, since 1981, have been six to eight times cleaner than cars in 1968. Total emissions have decreased because the emission reductions from fleet replacement have been greater than the emission increases caused by growth in the number of miles we drive our vehicles each year. But by 1994, the pre-1981 vehicles will largely have been replaced, and the emission offset against increasing auto use will be gone.

Vehicle miles traveled (VMT) are increasing nationally at about 2.5%/year, and in many growth areas are increasing at 4%, 5% and even 6%/year. At these growth rates, vehicle use will double in many urban areas by 2010. For example, the new transportation plan for Denver is based on an expected increase in vehicle miles travelled from 33 million to 63 million miles per day. Vehicle emissions will soon begin to grow at comparable rates. In Denver, for example, nitrogen oxide emissions are expected to increase 27% from 1995 to 2010, and particulate emissions will increase even faster. To prevent this ominous reversal in emission trends, new initiatives are needed to 1) reduce emissions from new vehicles by requiring manufacturers to install the best available pollution controls, 2) use cleaner burning fuels, and 3) reduce vehicle use trends, by offering less polluting transportation alternatives to the single-occupant vehicle.

All three approaches are needed to meet clean air goals over the long term. The tighter tailpipe standards now under consideration by Congress (i.e., S. 1984 in the last Congress, and H.R. 2323) will not reduce hydrocarbon emissions enough to offset VMT growth in many cities, and will barely keep pace with NOx emission increases resulting from VMT growth. Once the current fleet of vehicles has been replaced (EPA estimates 90% of vehicles are replaced in about 12 years), VMT growth will once again dominate emission trends. If we are to achieve ambient pollution levels cleaner than those found today in cities exceeding national health standards, then the proposed tighter tailpipe standards will not be enough. Greater improvements in emission performance will be needed along with policies aimed at slowing VMT growth.

ALTERNATIVE FUEL RESULTS OFFER PROMISE, BUT MIXED RESULTS ARGUE FOR SOME CAUTION.

Initial results from tests of methanol and compressed natural gas (CNG) as alternatives to gasoline and diesel fuel suggest that these fuels offer the promise of substantial improvements in emission performance. But the results are mixed.

DIESEL ENGINE EMISSIONS.

Diesel-powered trucks, buses and autos represent about 1% of the fleet in most urban areas, but account for 25% to 50% of fine particulate less than 2.5 um in size. Many diesel particles are highly carcinogenic. EPA estimates that "between 2% and 8% of the current non-smoker risk of contracting lung cancer in the U.S." is caused by diesel particulate matter. 49 Fed. Reg. 40260. Thus diesel emissions are one of the most significant causes of environmentally induced cancer.

Under EPA's current emission standards for diesel-powered trucks and buses, EPA projects that total emissions of particulate and NOx will continue to climb, although at a slower rate than if no standards had been adopted. With EPA's current standards, urban diesel particulate emissions will increase from 53,200 tons/year to 59,300 tons/ year between 1984 and 2000. 50 Fed. Reg. 10619. Similarly, NOx emissions from diesels will also increase at about the same rate. 50 Fed. Reg. 10617. Current regulatory requirements achieve no net improvement in urban air quality.

To achieve actual improvements in urban air quality, total emissions from diesel trucks and buses must be reduced over time. Alternative fuels offer some hope of achieving overall reductions in emissions. However, performance demonstrated to date has been mixed. Available data suggest there is a need for further research and development to address the potentially negative consequences of using alternatives to diesel fuel.

THE NEW YORK CITY BUS TESTS.

The most advanced program for the use of methanol as a bus fuel is the fleet of six buses operated by Tri-Borough Coach in New York City. The buses have been operated in commercial service in New York, and have been tested by the New York City Department of Environmental Protection. See "Emissions Characterization of the Detroit Diesel Methanol Bus Engine" (attached as Appendix A). The DEP test results demonstrate that methanol buses fitted with catalysts achieved particulate emissions about six times lower than comparable diesel buses, and achieved NOx emissions six to eight times lower. This level of emission performance suggests that performance better than the current EPA standards may be achieved, although direct comparisons cannot be made because the results are not reported in units comparable to those used by EPA.

However, the encouraging results for particulate and NOX are offset by high formaldehyde emissions (ranging from 20 to 250 times higher than the diesel buses), and unexpected increases in carbon monoxide (10 to 30 times higher than diesel) and hydrocarbon (3 to 40 times higher than diesel) emissions. The increases in hydrocarbon emissions seem to be capable of control using catalyst technology, however, it is not clear what will be needed to control increased carbon monoxide and aldehyde emissions.

In addition to the emission penalties for harmful pollutants such as formaldehyde and carbon monoxide, the New York City bus tests also demonstrate a severe loss in fuel efficiency. On an equivalent BTU basis, the methanol buses consumed over 50% more energy, on average, than the diesel buses. Such a large energy penalty is unacceptable from the standpoint of increased CO2 emissions and the adverse impact it would have on global climate change. This energy penalty would also have negative consequences for national energy security.

These results suggest 1) a need to consider the full array of pollutants emitted by alternative fuel vehicles that affect human health in the urban environment, and not just the two pollutants (particulate and NOx) regulated by EPA, when reviewing the performance of alternatives to diesel fueled engines, 2) the need for substantial investment in further research and development to determine whether the adverse affects of methanol can be adequately mitigated by design modification or after-combustion controls, and 3) a statement of policy by Congress regarding the acceptability of environmental trade-offs, i.e., whether substantially worse emission performance for some pollutants that impair human health will be tolerated in exchange for improvements in other pollutants.

EDF RECOMMENDATIONS FOR ALTERNATIVES TO DIESEL FUELED ENGINES.

EDF makes the following recommendations related to the development of alternatives to diesel-fueled vehicles:

--the impacts on human health and the urban environment from the use of diesel fuels are unacceptably high. A major effort should be made to find an environmentally acceptable alternative.

--the level of emission control required by EPA for new diesel buses (after 1991) and trucks (after 1994) are not sufficient since they only slow, and do not reverse, the trend toward deteriorating urban air quality.

--the potential for major improvements in emissions of particulate and NOx from alternate fuels must be fully explored.

--Congress should support a research and development program that investigates the options available to maximize the emission performance of alternate fuels.

--Any program aimed at assessing the desirability of alternative fuels should include consideration of all major pollutants known to have an adverse effect on human health, including the carcinogenic contaminants such as formaldehyde and other hydrocarbon species, and carbon monoxide. The evaluation should not be limited to the two pollutants (particulates and NOx) for which EPA has set standards.

--Congress should establish a national policy that alternative fuels be considered acceptable only if they can achieve effective improvements in the emission of some pollutants without causing increased public exposure to other harmful contaminants in the urban air. In the event EPA should conclude that a trade-off between pollutants is desirable on public health grounds, i.e., that a shift in fuels would offer a net public health benefit, then EPA should be invited to ask Congress to modify this policy. EPA should not be given authority to make such trade-off decisions without Congressional review and approval.

--Congress should add greenhouse gas emission factors criteria for reviewing and assessing the benefits of alternative fuels. The energy penalty demonstrated to date in the use of methanol as a diesel substitute would have negative impacts on global climate change and is not acceptable. Currently EPA is not required to consider fuel efficiency in determining the acceptability of alternative fuels. This factor should be added to the Clean Air Act as CO2 and methane emission standards that apply uniformly to the entire production cycle of each fuel under consideration.

--EPA should be required to review the current diesel standards after an adequate opportunity has been allowed for the engine manufacturers and fuel producers to develop the improvements needed to remedy the adverse effects of methanol fuel use to date. About 1994, EPA should be required to reconsider the existing diesel standards to determine if expected technology developments and alternative fuels can achieve better emission performance than is currently required. If better performance can be achieved, then the public should be assured of the benefits of that performance by setting standards that require the manufacture of vehicles capable of achieving optimal emission reductions.

The terror of EDF's recommendations may appear hostile to the use of alternatives to diesel oil. This is not our intent. Based on the sparse data, and limited research commitment aimed at optimizing the benefit of methanol as an alternative fuel, we must conclude methanol has not yet demonstrated a major environmental benefit. But the effort has shown some promising results and must not be killed in its infancy. The manufacturers and fuel producers are hopeful they can successfully remedy the adverse impacts represented by increased emissions of hydrocarbons and carbon monoxide, and eliminate the energy penalty. Congress should encourage this effort because the environmental costs of continuing to burn diesel oil are high.

But until the adverse impacts of the alternatives are eliminated, Congress should not assume that alternatives to diesel fuel offer a quick and simple solution to either the urban air pollution problem or concerns about energy efficiency.

GASOLINE VEHICLE EMISSIONS.

As with diesel fuel, the nation suffers major public health costs and environmental degradation from the universal use of gasoline. NOx and hydrocarbon emissions from gasoline-fueled vehicles are the single largest contributor to ozone formation in urban areas around the nation. Last year over 150 million Americans were exposed to levels of ozone known to damage lungs and trigger acute attacks among asthmatics and others sensitive to ozone. Tailpipes also contribute about 40% of the NOX that causes acid rain.

Gasoline is also virtually the only source of benzene in the human environment. The production, transport, fueling and combustion of gasoline accounts for 99% of benzene exposure. A California report attributed 83% of benzene emissions to auto tailpipes. The California Air Resources Board estimates this causes between 100 and 1,000 leukemia deaths in the South Coast air basin annually. On a national basis, benzene exposure could account for half or more of the 17,000 leukemia deaths each year.

It should be a high priority of the nation to seek fuels that will eliminate the cancer risk from benzene and provide substantial reductions in the emissions that cause hazardous ozone levels and acid rain.

CNG MAY OFFER LARGE CARBON MONOXIDE BENEFITS.

Alternatives to gasoline as a fuel for light duty vehicles have in some tests demonstrated substantial emission improvements. For example, a joint testing program conducted by the Colorado Department of Health and the Public Service Company of Colorado evaluated the emission performance of CNG-fueled light duty trucks and vans. See "The Effects of Compressed Natural Gas on Exhaust Emissions, Fuel Economy and Power at High Altitudes" (attached as Appendix B). The test vehicles were fitted with a CNG conversion kit that allowed dual operation on both gasoline and CNG. Four vehicles were tested before the retrofit, and then again after the retrofit. Tests were performed using the EPA's federal test procedure. While burning CNG, the vehicles achieved an average reduction of carbon monoxide emissions of 98.4% compared to pre-retrofit operation on gasoline.

CO Emission Performance (g/mi)

Vehicle	Gasoline	CNG
'81 Ford Van	57.61	0.35
'78 Chevy Pickup	73.63	2.18
'84 Chevy Van	22.70	0.02
'86 Chevy Pickup	6.26	0.08

Large reductions in non-methane hydrocarbons were also achieved, although when methane is included, total hydrocarbons increased somewhat. NOx emissions increased significantly with two vehicles, remained unchanged with one, and improved with the older, non-catalyst equipped '78 vehicle. These data show a dramatic improvement in CO emission performance at the possible expense of a NOx emission penalty. Engineers in the field argue that the NOx penalty might be eliminated in a dedicated CNG vehicle designed to optimize emission performance. Such a vehicle would not contribute to improved air quality where NOX is a major cause of ambient air quality violations, but could contribute to major improvements in areas where CO is the problem. Additional research is needed to ensure that the CO improvement could be achieved without a NOx penalty.

METHANOL EMISSION BENEFITS

Dual-fueled vehicles tested in California show that methanol, too, can achieve substantial reductions in emissions of ozone precursors, NOx and some reactive hydrocarbons. These data also raise concern about possible increases in formaldehyde emissions. These emissions, if large enough, could offset the benefits of the reductions in other hydrocarbon species.

California has proposed to address this possible negative impact by requiring methanol-fueled vehicles to achieve formaldehyde emission rates comparable to the levels emitted by gasoline vehicles. The U.S. EPA has refused to adopt such a policy for methanol-fueled cars sold outside of California. The California policy establishes clear guidelines to be met by the industry, and assures the public that a switch to methanol will not result in increased exposure to the major contaminant associated with methanol. It is also a policy designed to maximize the ozone pollution benefits derived from conversion to methanol.

EDF supports the California approach toward minimizing the known hazard associated with methanol. We urge the Congress to establish a similar policy for the nation before the California experiment with methanol is adopted in other high pollution areas. There is no rational basis for EPA's refusal to adopt formaldehyde standards that establishes a goal for methanol engines to meet levels comparable to gasoline.

GREENHOUSE GAS EMISSIONS NEED LEGAL RESTRAINTS.

Importantly, the Colorado CNG tests demonstrated a marked improvement in overall greenhouse gas emissions. When operated on CNG, CO2 emissions decreased by about 25%, along with the decrease in CO emissions. There was a slight CO2 penalty, however, when the converted vehicles were operated on liquid fuel instead of CNG.

Offsetting the CO2 emission benefit was an increase in methane emissions, which is another greenhouse gas. During the tests methane emissions increased approximately 2 g/mi, while CO2 emissions dropped 155 g/mi. Thus, even considering the greater greenhouse effectiveness of methane compared to CO2, there would appear to be a net reduction in greenhouse gas effect from the use of CNG.

This benefit is limited to the combustion products from the engine, and do not include full fuel cycle emissions. Any meaningful comparison of fuels on the basis of potential greenhouse effect should include all the emissions of both gases from the extraction, production, refining, transport, handling and combustion of fuels.

A full fuel cycle analysis of greenhouse gas emissions needs to be included as a criteria for the evaluation of alternative fuels. It is essential as we consider the possibility of developing a new fuel infrastructure to serve transportation needs in the U.S. that we not commit major capital resources to a system that will exacerbate global climate change. For this reason, the environmental community is united in opposition to a methane-based fuel system that might ultimately be derived from coal. Current estimates show that coal-derived methanol would result in at least a 50% increase in CO2 emissions compared to current oil-derived fuels. Such a result is not acceptable since transportation sources already account for 30% of CO2 emissions from the U.S., and the U.S. emits 25% of the world's total CO2. Currently, most methanol is produced from natural gas. Gas-derived methanol appears to give a slight CO2 benefit compared to gasoline.

To preclude the possibility of coal-derived methanol from entering the market, Congress should direct EPA to set fuel-neutral emission standards for CO2 and methane that would apply to an entire fuel cycle. These standards would then establish a legally enforceable basis for comparing the greenhouse impact of competing fuels, and foreclose fuel production technologies that would substantially increase the greenhouse impact of any given fuel.

FUEL COMPETITION PROGRAM FOR THE 90'S.

EDF urges Congress to establish a national competition between fuels during the 90's to determine which fuel will become the dominant auto source for the 21st Century. The competition should be defined by the enactment of a second round of tailpipe emission standards that would become effective in 1998. These tighter standards should include the existing criteria pollutants and ozone precursors (carbon monoxide, nitrogen oxides, hydrocarbons), but should also include zero emissions of benzene and fuel-cycle standards for CO2 and methene.

These standards would have the effect of directing the research and development resources of the nation, from the largest corporation in the fuel and manufacturing sectors of the economy, to the basement inventor, to invest in the search for the optimal mix of on-board control technology and least polluting fuels. The program would be given some flexibility by allowing EPA the discretion to annually slip the deadlines for meeting the standards until the year 2000 based on findings of unreasonable cost or technical infeasibility. If the standards were not ultimately met, Congress would have to revisit the standards as it did in 1977 when the Clean Air Act's original tailpipe standards were not met.

To guide this competition, Congress needs to make one rule clear: all fuels are treated equally. There would no longer be an assumption that only gasoline and diesel will fuel America's cars and trucks in the next century. Every fuel would be given its chance to demonstrate its benefits and to claim the market of the future. EPA would be directed to make its determinations of feasibility on the best demonstrated performance of the optimal combination of fuels AND technology.

Only with such a competition can we expect the nation to engage in a search for the fuel that will best protect the health of urban Americans while at the same time minimizing the impact of energy use in the transportation sector on the global life support system. The pollution increases projected for the post-1995 era demand that we begin now to develop pollution control strategies capable of protecting the city dwellers of the future and stabilizing the global atmosphere. There is no time to wait.

Respectfully submitted,

Robert E. Yuhnke

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Senior Attorney

APPENDIX A

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Department of
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Bureau of Environmental Management
2420 Municipal Building, New York 10007 (212) 669-7698

HARVEY W. SCHULTZ
Commissioner

MIRA BARER
Deputy Commissioner

EMISSIONS CHARACTERIZATION OF THE DETROIT DIESEL METHANOL BUS ENGINE

Harvey W. Schultz
Commissioner

Mira Barer
Deputy Commissioner

Geraldine Kelpin
Director, Division of Environmental Management and Policy

Prepared by: Laslo Goldberger
Mark Simon

CITY OF NEW YORK

DEPARTMENT OF ENVIRONMENTAL PROTECTION

APRIL, 1989

This is 100% recycled paper.

INTRODUCTION

This report summarizes the emissions from six methanol bus engines built by Detroit Diesel Corporation. They are being operated in General Motors coaches by the Triboro Coach Company in Queens, New York. The first round of Diesel control bus and methanol bus testing was performed in May, 1988. A second round of methanol testing was performed in December, 1988. Emissions testing took place at the emissions test laboratory of the New York City Department of Environmental Protection located in Brooklyn, New York.

METHODOLOGY

Each data point presented in this report represents an average of two complete tests performed on a chassis dynamometer over two concurrent days. These "back to back duplicate" tests are presented for the NY Bus Cycle and the NY Composite Cycle (defined below).

> NEW YORK BUS CYCLE- Developed by the NYC Department of Environmental Protection to simulate rush hour traffic conditions in Manhattan. This chassis dynamometer cycle has an average speed of 3.9 miles/hour and represents the severe stop and go nature of the Central Business District driving patterns. The cycles covers .65 miles over a 10 minute test period.
>
> NEW YORK COMPOSITE CYCLE- Developed by Systems Control, Inc. for USEPA to simulate average city-wide New York City traffic. The average speed of this chassis dynamometer cycle is 8.8 miles/hour and it covers 2.5 miles over 17 minute period.

There are two approaches to heavy duty engine emissions testing. The engine can be removed from the vehicle and emissions tested by simulating a driving cycle on the engine or the entire bus can be "driven" in place with the rear wheels turning a chassis dynamometer. Heavy duty testing of buses on a chassis dynamometer represents a specialized, non-routine test; which best emulates real world conditions. There are currently no comprehensive EPA test procedures for this type of work. NYCDEP has drawn on portions of published light duty vehicle testing procedures, heavy duty engine testing procedures and good engineering practices to develop the above referenced dynamometer test cycles as well as the procedures to collect and analyze the emissions.

The six methanol buses accumulated approximately 20,000 miles each. Two of the buses (M1,M2) were driven without a catalyst. A silver catalyst was placed on M3, silver/platinum on M4 and M5 and a platinum catalyst on M6. The purpose of driving buses uncatalyzed was to set a baseline for judging catalyst effectiveness. Platinum was used to judge the effectiveness of an oxidation catalyst, silver also an oxidation catalyst was utilized to reduce formaldyhyde emissions.

The emission levels from the Federally regulated pollutants of hydrocarbons, carbon monoxide, nitrogen oxides and particulates were determined by conventional analytical instrumentation. Non-regulated emissions of methanol were measured using an FTIR built by Nicolet. This is the first application of using an FTIR in a chassis dynamometer auto emissions laboratory and NYCDEP has been working with Nicolet to resolve operational and calibration issues. Aldehyde emissions are only presented as trend data in this report because different FTIR's were used on the two different rounds of testing. As the two FTIR's are new and issues related to the calibration of this equipment for vehicle emission tests are still unresolved, DEP did not have sufficient confidence in the results to present the data as anything more than trend data. Unlike conventional instumetnation calibration of the FTIR is done utilizing a preexisting program on the machines hard disk. No calibration gases are used. Until all issues related to the calibration of this equipment are resolved to the satisfaction of NYCDEP and USEPA, subsequent aldehyde samples will be analyzed by "wet chemistry" technique at the EPA Ann Arbor lab. Fuel consumption in terms of BTU/mile is also presented.

To control for any residual particulate that may be remaining in the dilution tunnel from diesel bus tests, the dilution tunnel is thoroughly high pressure steam cleaned and reseasoned prior to testing of the methanol buses. This was not done as part of the round one testing. The relatively high levels of particulate found in the methanol bus testing during round one prompted DEP and USEPA to question whether some of the particulate was residue from previous tests that was being blown off of the dilution tunnel. This procedural change should be considered when examining the particulate data.

The emissions data presented in this report is best characterized as a representation of the differential between the two technologies (diesel and methanol). The data is representative of a specific set of testing conditions. These numbers are most meaningful when compared to data collected under the same vehicle testing conditions. Therefore judgement must be used not only in comparing test results using different test cycles (i.e. NYC Bus Cycle and NYC Composite) but more importantly those using different test conditions for the same cycles(ie inertia weight settings). It would also be inappropriate to compare these results to those derived from engine dynamometer testing. EPA and DEP believe that the important factor to consider is the differential between data generated from the same test facility involving various engine and fuel technologies.

EMISSIONS

The following summary is derived from the raw data sheets which are attached as an appendix to this report. The appendix includes six pages of raw data as well as data on formaldehyde emissions. The data has also been graphically presented for comparison. These graphs, which clearly show trends, will be referred to in the summary of emissions results. Diesel technology and DEP familiarity with diesel buses is such that round one numbers were considered reflective of typical diesel emissions under the NYC bus and NYC Composite cycles; therefore no round two data was taken. No significant emissions deterioration has traditionally occurred in diesels between 20,000 and 40,000 miles of operation.

Particulates

Particulate levels in the catalyzed methanol buses (M3-M6) were much lower than the diesel controls (see graph 1). NYC bus cycle levels ranged from .23 to .39 gm/mile in methanol as compared to .99-1.73 gm/mile in the diesel buses. NYC Composite cycle levels ranged from .14-.19 gm/mile methanol compared to .57-.85 gm/mile diesel. Uncatalyzed emissions in bus M1 were actually higher than the average of the diesel controls (see graph 1). As stated earlier DEP changed its testing procedure between round one and round two particulate emissions testing. This decision to clean the dilution tunnel between diesel and methanol tests makes a comparison to round one methanol particulate levels inappropriate.

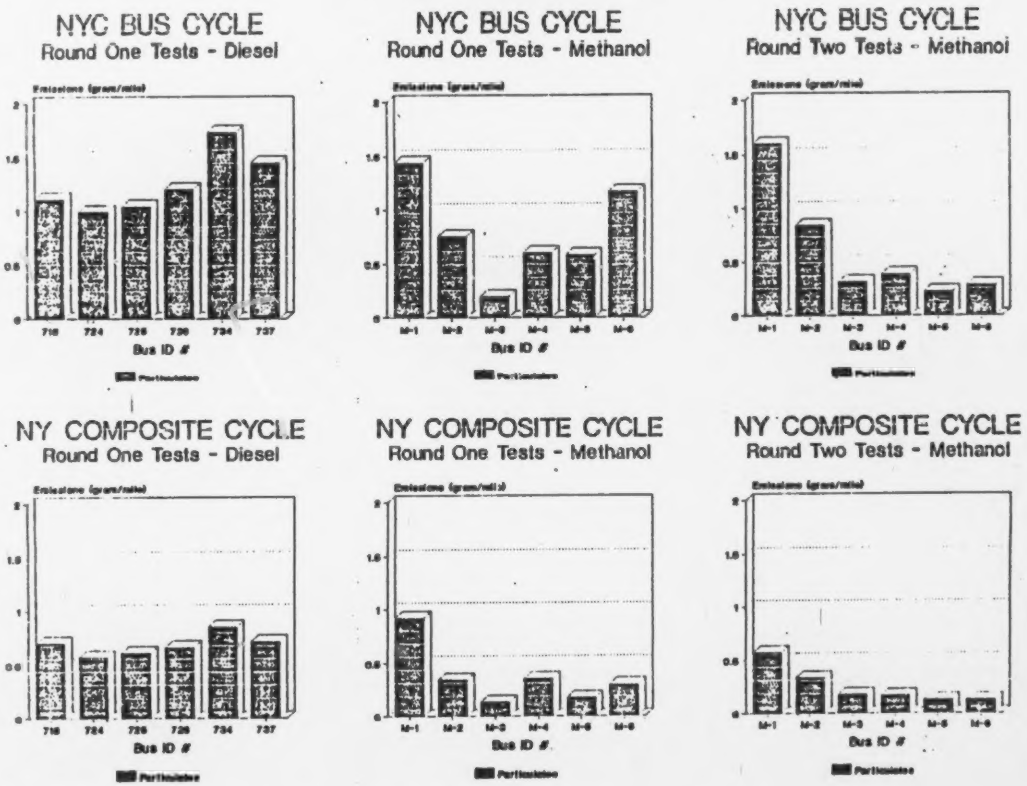
Formaldehydes.

All methanol buses emit substantially higher levels of formaldehyde than the diesel control buses. As can be seen from the round one data (attached in the appendix) diesel aldehyde levels range from 0 to .02 grams/mile while methanol level varied between .42 and 4.96 grams/mile. The trend data appears to show an increase in formaldehyde emissions between rounds of testing in three of the four catalyzed buses (the exception was bus M-4).

Hydrocarbons(HC). HC levels in diesels range from approximately 5.5 gm/mile during the low speed NYC bus cycle to approximately 2.5 gm/mile in the NYC composite cycle (see graph 3). Methanol buses ranges from 8.3 gm/mile to 273 gm/mile in the NYC bus cycle and 6-99 gm/mile in the NYC composite cycle. In the case of M100 fueled methanol buses hydrocarbons are represented by unburned methanol. The emissions from the second round of testing were dramatically higher in the catalyzed buses and just slightly higher in the uncatalyzed buses. M4 hydrocarbon emissions rose from 92 grams/mile to 634gm/mile in the largest increase. Correspondingly the mileage rate of the bus dropped form .76 miles/gallon to .64 miles/gallon.

Oxides of Nitrogen. NOx levels in methanol buses are much lower than in diesels. Methanol bus emissions ranged from 10-12 gm/mile in the NYC bus cycle and 6-8 gm/mile in the NYC composite cycle. Diesels bus levels ranges from 85-91 gm/mile in the NYC bus cycle and 39-42 gm/mile in the NYC composite cycle. NOx levels decreased by about 10% in the methanol buses between round one and round two.

GRAPH 1
PARTICULATES



NYC BUS CYCLE
Round One Tests - Diesel

NYC BUS CYCLE
Round One Tests - Methanol

NYC BUS CYCLE
Round Two Tests - Methanol

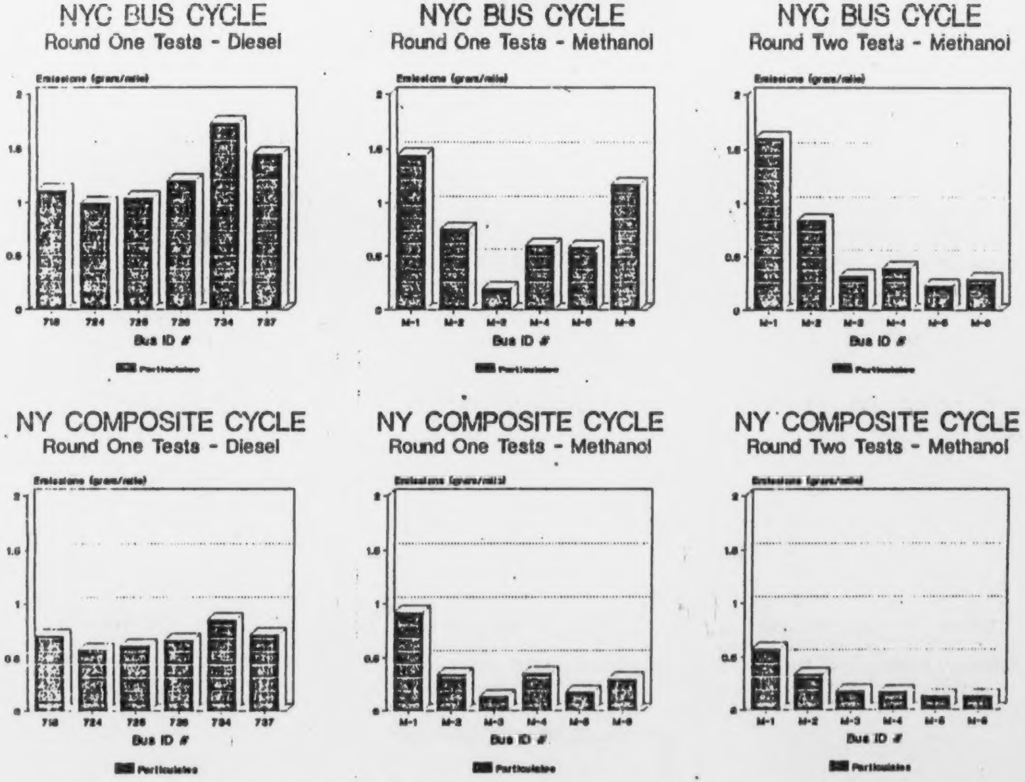
NY COMPOSITE CYCLE
Round One Tests - Diesel

NY COMPOSITE CYCLE
Round One Tests - Methanol

NY COMPOSITE CYCLE
Round Two Tests - Methanol

1) Catalysts: M1 & M2 (None); M3 (Si); M4 & M5 (Si/Pt); M6 (Pt)
2) Tests conducted at NYC DEP Emission Lab in May, 1988 (Round 1) and December, 1988 (Round 2)

GRAPH 1
PARTICULATES



NYC BUS CYCLE
Round One Tests - Diesel

NYC BUS CYCLE
Round One Tests - Methanol

NYC BUS CYCLE
Round Two Tests - Methanol

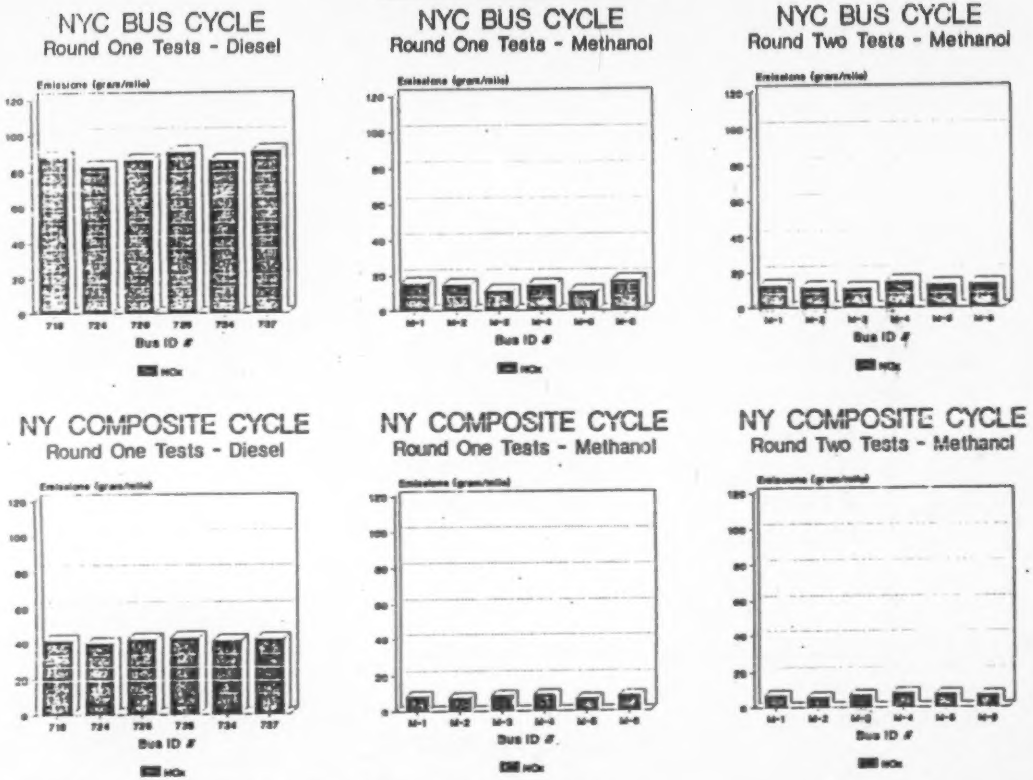
NY COMPOSITE CYCLE
Round One Tests - Diesel

NY COMPOSITE CYCLE
Round One Tests - Methanol

NY COMPOSITE CYCLE
Round Two Tests - Methanol

1) Catalysts: M1 & M2 (None); M3 (Si); M4 & M5 (Si/Pt); M6 (Pt)
2) Tests conducted at NYC DEP Emission Lab in May, 1988 (Round 1) and December, 1988 (Round 2)

GRAPH 2
NOx



NYC BUS CYCLE
Round One Tests - Diesel

NYC BUS CYCLE
Round One Tests - Methanol

NYC BUS CYCLE
Round Two Tests - Methanol

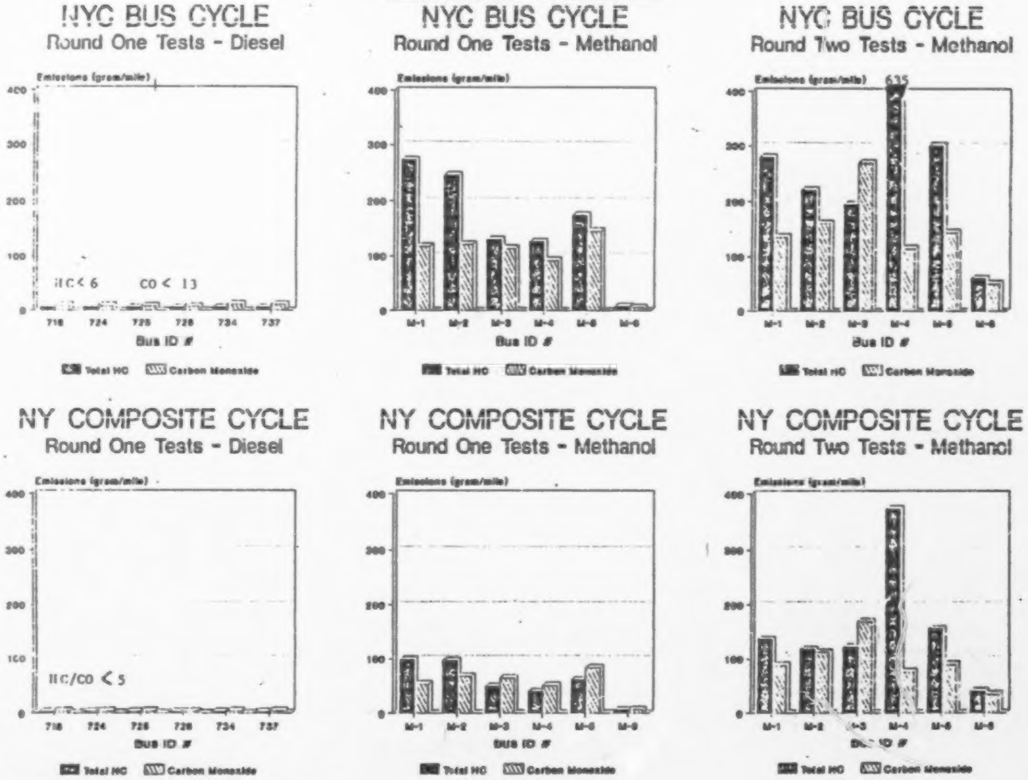
NY COMPOSITE CYCLE
Round One Tests - Diesel

NY COMPOSITE CYCLE
Round One Tests - Methanol

NY COMPOSITE CYCLE
Round Two Tests - Methanol

1) Catalysts: M1 & M2 (None); M3 (Si); M4 & M5 (Si/Pt); M6 (pt)
2) Tests conducted at NYC DEP Emission Lab in May, 1988 (Round 1) and December, 1988 (Round 2)

GRAPH 3
CO/HC



1) Catalysts: M1 & M2 (None); M3 (Si); M4 & M5 (Si/Pt); M6 (Pt)
2) Tests conducted at NYC DEP Emission Lab in May, 1988 (Round 1) and December, 1988 (Round 2)

APPENDIX

METHANOL - BUS PROGRAM ROUND 2

N.Y.C. BUS CYCLE

				EMISSIONS (g/m)						FUEL CONSUMPTION		
ID	FUEL	MILES	HRS	HC	CO	NO_x	PART.	ALD.	METH.	ML/GL	BTU/MILE	CONTROLS
M-1	M	19,402	2668	279.4	135.1	12.7	1.16			0.75	76,523	NO CATALYST
M-2	M	25,971	2796	221.0	160.2	11.3	0.84			0.77	74,369	NO CATALYST
M-3	M	23,144	2808	194.9	296.9	10.8	0.32			0.71	80,290	SILVER
M-4	M	26,005	3025	634.6	114.6	14.6	0.39			0.64	89,870	SILVER PLATINUM
M-5	M	24,100	2682	301.1	144.1	12.8	0.23			0.73	78,339	SILVER PLATINUM
M-6	M	16,838	2756	60.7	51.0	13.2	0.29			0.78	73,176	PLATINUM

HC - hydrocarbon
CO - carbon monoxide
NO_x- oxides of nitrogen

PART.- particulates
ALD. - aldehydes
METH.- methanol

FUEL
D - diesel
M - methanol

METHANOL - BUS PROGRAM ROUND 2

N. Y. COMPOSITE

				EMISSIONS (g/m)						FUEL CONSUMPTION		
ID	FUEL	MILES	HRS	HC	CO	NO_x	PART.	ALD.	METH.	ML/GL	BTU/MILE	CONTROLS
M-1	M	19,402	2668	135.5	88.4	7.1	0.57			1.51	37,803	NO CATALYST
M-2	M	25,971	2796	117.1	112.2	6.0	0.34			1.54	36,980	NO CATALYST
M-3	M	23,144	2808	121.7	168.9	7.1	0.19			1.34	42,762	SILVER
M-4	M	26,005	3025	373.6	76.6	8.3	0.18			1.22	47,151	SILVER PLATINUM
M-5	M	24,100	2682	155.2	90.1	7.7	0.14			1.46	39,100	SILVER PLATINUM
M-6	M	16,838	2756	41.5	35.5	7.3	0.14			1.56	36,685	PLATINUM

HC - hydrocarbon
CO - carbon monoxide
NO_x- oxides of nitrogen

PART.- particulates
ALD. - aldehydes
METH.- methanol

FUEL
D - diesel
M - methanol

APPENDIX 13 (CONTINUED)

METHANOL - BUS PROGRAM ROUND 1

NY BUS CYCLE

				EMISSIONS (g/m)						FUEL CONSUMPTION			
ID	FUEL	MILES	HRS	HC	CO	NO_x	PART.	ALD.	METH.	ML/GL	TU/MILE	CONTROLS	
718	D	27778	3199	5.45	10.12	87.69	1.11	0.02	0.00	2.46	51339	NO CATALYST	
724	D	28221	2932	5.56	9.14	82.05	0.99	0.00	0.00	2.48	50849	NO CATALYST	
725	D	24996	3263	5.19	8.81	85.69	1.04	0.02	0.00	2.47	51044	NO CATALYST	
726	D	28155	3326	5.23	7.80	90.36	1.20	0.00	0.00	2.46	51382	NO CATALYST	
734	D	26315	2986	5.95	12.36	85.46	1.73	0.01	0.00	2.56	49285	NO CATALYST	
737	D	37949	3286	5.24	11.88	90.96	1.45	0.00	0.00	2.46	51378	NO CATALYST	

HC - hydrocarbon
CO - carbon monoxide
NO_x- oxides of nitrogen

PART.- particulates
ALD. - aldehydes
METH.- methanol

FUEL
D - diesel
M - methanol

METHANOL - BUS PROGRAM

NY COMPOSITE CYCLE

				EMISSIONS (g/m)						FUEL CONSUMPTION		
ID	FUEL	MILES	HRS	HC	CO	NO_x	PART.	ALD.	METH.	ML/GL	BTU/MILE	CONTROLS
718	D	27778	3199	2.34	3.83	41.17	0.70	0.00	0.00	4.75	27600	NO CATALYST
724	D	28221	2932	2.60	3.39	39.36	0.57	0.01	0.00	4.65	27126	NO CATALYST
725	D	24996	3263	2.44	3.32	41.68	0.61	0.01	0.00	4.49	28076	NO CATALYST
726	D	28155	3326	2.38	3.05	42.70	0.66	0.01	0.00	4.64	27173	NO CATALYST
734	D	26315	2986	2.54	4.17	40.91	0.85	0.01	0.00	4.75	26527	NO CATALYST
737	D	37949	3286	2.35	4.51	41.74	0.71	0.00	0.00	4.80	26261	NO CATALYST

HC - hydrocarbon
CO - carbon monoxide
NO_x- oxides of nitrogen

PART.- particulates
ALD. - aldehydes
METH.- methanol

FUEL
D - diesel
M - methanol

METHANOL - BUS PROGRAM ROUND 1

				NYC BUS CYCLE EMISSIONS (g/m)						FUEL CONSUMPTION		
ID	FUEL	MILES	HRS	HC	CO	NO$_x$	PART.	ALD.	METH.	ML/GL	BTU/MILE	CONTROLS
M-1	M	39	74	273.37	117.09	15.70	1.44	3.71	267.89	0.74	76,750	NO CATALYST
M-2	M	50	82	246.48	120.97	14.62	0.75	4.96	260.71	0.73	78,497	NO CATALYST
M-3	M	65	68	129.19	113.50	11.20	0.20	0.71	141.03	0.78	73,335	SILVER
M-4	M	30	28	125.91	92.24	14.45	0.60	1.66	143.69	0.76	74,936	SILVER/PLATINUM
M-5	M	1,876	265	174.04	145.16	10.69	0.58	2.55	173.39	0.81	70,450	SILVER/PLATINUM
M-6	M	28	66	8.32	7.04	16.93	1.17	3.32	8,39	0.82	69,818	PLATINUM

HC - hydrocarbon
CO - carbon monoxide
NO$_x$ - oxides of nitrogen

PART.- particulates
ALD. - aldehydes
METH.- methanol

FUEL
D - diesel
M - methanol

METHANOL - BUS PROGRAM ROUND 1

NY COMPOSITE CYCLE

				EMISSIONS (g/m)						FUEL CONSUMPTION		
ID	FUEL	MILES	HRS	HC	CO	NO_x	PART.	ALD.	METH.	ML/GL	BTU/MILE	CONTROLS
M-1	M	39	74	98.64	54.06	8.70	0.92	1.62	97.46	1.60	35,694	NO CATALYST
M-2	M	50	82	96.55	68.40	7.82	0.35	1.99	104.17	1.56	36,566	NO CATALYST
M-3	M	65	68	49.71	65.12	8.98	0.15	0.42	56.84	1.65	34,687	SILVER
M-4	M	30	28	40.19	51.49	9.67	0.36	0.86	43.90	1.60	35,709	SILVER/ PLATINUM
M-5	M	1,876	265	61.63	84.11	7.20	0.18	1.49	65.86	1.71	33,370	SILVER/ PLATINUM
M-6	M	28	66	5.76	6.87	8.99	0.30	2.26	5.44	1.68	33,990	PLATINUM

HC - hydrocarbon
CO - carbon monoxide
NO_x- oxides of nitrogen

PART.- particulates
ALD. - aldehydes
METH.- methanol

FUEL
D - diesel
M - methanol

RELATIVE FORMALDEHYDE EMISSIONS

PERCENT CHANGE IN FORMALDEHYDE EMISSIONS
RELATIVE TO M-1 & M-2 (NO CATALYST)

ROUND 1

CYCLE	M-1 & M-2 NO CATALYST	M-3 SILVER	M-4 SILV.-PLAT.	M-5 SILV.-PLAT.	M-6 PLATINUM
N.Y.C. BUS	———	-85.0	-59.9	-38.4	-28.8
N.Y. COMPOSITE	———	-76.8	-52.5	-17.7	+24.9

ROUND 2

CYCLE	M-1 & M-2 NO CATALYST	M-3 SILVER	M-4 SILV.-PLAT.	M-5 SILV.-PLAT.	M-6 PLATINUM
N.Y.C. BUS	———	+52.7	-59.4	+43.0	+117.0
N.Y. COMPOSITE	———	+87.4	-36.5	+58.6	+135.5

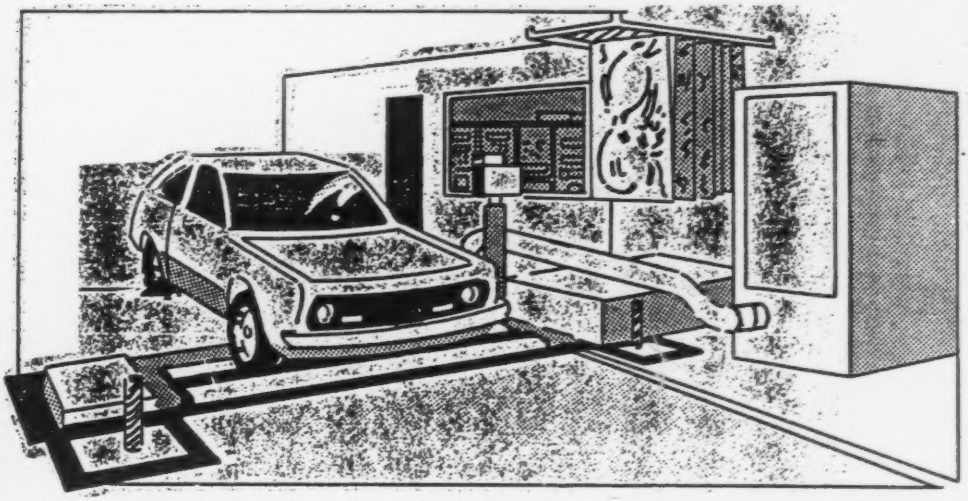
RATIO OF FORMALDEHYDE EMISSIONS FOR THE TWO ROUNDS OF TESTING

$$\frac{\text{Formaldehyde Round-2}}{\text{Formaldehyde Round-1}}$$

CYCLE	M-1	M-2	M-3	M-4	M-5	M-6
N.Y.C. BUS	2.94	1.93	23.67	2.36	5.41	7.09
N.Y. COMPOSITE	3.05	2.61	22.62	3.74	5.40	5.28

Appendix B

THE EFFECTS OF COMPRESSED NATURAL GAS on EXHAUST EMISSIONS, FUEL ECONOMY and POWER at HIGH ALTITUDES



PREPARED BY
COLORADO DEPARTMENT OF HEALTH
AIR POLLUTION CONTROL DIVISION
MOBILE SOURCES PROGRAM
AURORA VEHICLE EMISSIONS TECHNICAL CENTER

THE EFFECTS OF COMPRESSED NATURAL GAS ON EXHAUST EMISSIONS, FUEL ECONOMY, AND POWER AT HIGH ALTITUDES

Prepared by
Colorado Department of Health
Air Pollution Control Division
Mobile Sources Program
Aurora Vehicle Emissions Technical Center

GENERAL INFORMATION

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We would also like to express our gratitude to Public Service Company, Colorado Interstate Gas, Westgas and J.R. Allsup of the National Institute of Petroleum Energy Resources for their comments, suggestions, and technical assistance in the preparation of this report.

EXECUTIVE SUMMARY

In order to study the effects of Compressed Natural Gas (CNG) on exhaust emissions, fuel economy, and performance, three light duty trucks (LDT) and one heavy light duty truck (HLDT) were retrofitted with CNG conversion kits. These kits enable the vehicles to be operated on either gasoline or CNG. To determine the immediate effects of this conversion, all four vehicles underwent baseline exhaust emissions testing on indolene fuel prior to installation of the kits and were retested after installation on both Indolene and CNG. The test vehicles were evaluated by both the Federal Test Procedure (FTP) and the Highway Fuel Economy Test (HFET).

Results of the testing were as follows:

Carbon monoxide emissions were reduced an average of 98.4 percent (39.3 g/mi) for CNG but increased an average of 19.2 percent (7.8 g/mi) for Indolene operation with the kit installed according to the FTP.

Average FTP NO_x emissions for two of the four vehicles tested increased 115.5 percent (1.5 g/mi) on CNG but NO_x emissions for the third vehicle decreased 51.7 percent (2.2 g/mi) and NO_x emissions for the fourth vehicle decreased 4.3 percent (0.1 g/mi) on CNG.

For CNG operation, total hydrocarbon emissions increased an average of 18.6 percent (0.4 g/mi) as measured by the FTP but the reactive components, non-methane HC's, are expected to decrease by 30 to 70 percent. For Indolene with the kit installed, total HC increased an average of 16.9 percent (0.4 g/mi).

Total aldehydes decreased an average of 9.6 percent (2.78 mg/mi) while formaldehyde increased an average of 60.4 percent (8.4 mg/mi) on CNG. Acetaldehyde decreased an average of 30.0 percent (0.9 mg/mi), acrolein decreased an average of 67.4 percent (0.8 mg/mi) on CNG. (Aldehydes were not measured on the HFET nor for Indolene with the CNG conversion kit installed.)

Total reactivity due to hydrocarbon and aldehyde emissions was estimated at about 75 percent lower than the total reactivity from Indolene exhaust without the kit.

Particulate emissions decreased an average of 5.4 percent (2.0 mg/mi) on Indolene with the kit installed and may have decreased by as much as 53.7 percent (19.9 mg/mi) on CNG.

FTP carbon dioxide emissions were reduced an average of 25.6 percent (154.5 g/mi) for CNG but increased an average of 1.7 percent (10.3 g/mi) for Indolene with the kit.

Fuel economy on CNG increased an average of 5.7 percent (0.8 mpg) on the FTP but decreased an average of 11.5 percent (2.0 mpg) on the HFET. Fuel economy on Indolene after installation of the kit decreased an average of 3.4 percent (0.5 mpg) and 3.3 percent (0.6 mpg) on the FTP and the HFET respectively.

Peak horsepower and torque were reduced an average of 24.3 percent (22.5 hp) and 22.5 percent (457 ft-lb) respectively for CNG. (Horsepower and torque were not evaluated for Indolene with the kit installed.)

INTRODUCTION

Air pollution continues to be a serious problem along the front range of Colorado. Carbon monoxide (CO), predominately from motor vehicles is a major health hazard. Several strategies such as the Automobile Inspection and Readjustment (AIR) Program, the Federal Motor Vehicle Emission Control Program, the Better Air Campaign (BAC), and the Oxygenated Fuels Program have been put into effect. Even with these programs in operation, reaching attainment of the Federal CO standard of 9 ppm remains an elusive goal.

In striving to protect the health of Colorado's citizens the Mobile Sources Section of the Air Pollution Control Division is constantly seeking out and evaluating other strategies that could prove effective in reducing air pollution. Alternative fuels such as propane, compressed natural gas (CNG), and neat methanol have the potential to reduce CO emissions from motor vehicles.

Because of the promise indicated by other studies [1, 2, 3] for the alternative fuel CNG in reducing CO emissions, the Colorado Department of Health has initiated a limited, long term evaluation of this fuel. This study, phase one of which will be described herein, is a cooperative effort between the Colorado Department of Health (CDH), Public Service Company of Colorado (PSCO), and Colorado Interstate Gas (CIG). The following report compares the results of baseline emissions testing of four vehicles on a standard hydrocarbon fuel (Indolene) to the results for CNG. Information is presented on regulated and non-regulated pollutants, fuel economy, and power. The test vehicles are capable of operation on either CNG or gasoline.

CNG STUDY OBJECTIVES

The objectives of the CNG study are to evaluate both the immediate and the long term (one year) effects on emissions performance of four test vehicles. The two primary tasks are: 1. To quantify the regulated emissions performance of these vehicles first on gasoline before conversion to CNG operation, then on CNG after conversion, and finally again on gasoline with the conversion kit installed; and 2. To evaluate the regulated emissions performance over a one year period in order to determine a deterioration rate and obtain durability data on the CNG conversion kit utilized in the study. Secondary tasks include quantifying differences in particulate emissions, aldehyde emissions, fuel economy and power between gasoline (Indolene) and CNG.

CNG STUDY TEST VEHICLES

Four test vehicles are involved in this evaluation. Three are light duty trucks (LDT's) with GVWR's of 6000 pounds or less, the fourth is a heavy light duty truck (HLDT) with a GVWR of 8200 pounds. The vehicles were selected as being representative of typical light duty fleet vehicles servicing the greater Denver Metro Area. An exact description of each vehicle is provided in Appendix A.

All vehicles received a complete tune up prior to the study. Engine oil, spark plugs, PCV valves, and air, oil, and PCV filters were replaced. Cylinder balance tests were performed to verify mechanical integrity and engine parameters such as ignition timing, idle speed and mixture were set to manufacturers specifications. All of the required emission control devices and systems were in place and operational.

TEST PROCEDURE

Each vehicle underwent the following tests after being accepted.

1. Fueled with Indolene test fuel
2. Full power chassis dynamometer testing
3. Federal Test Procedure (FTP)
4. Loaded steady state test at 50, 40, and 30 mph
5. Highway Fuel Economy Test (HFET)

Each vehicle was subjected to either two or three back to back FTP's to determine test variability for CO. Upon completion of the Indolene testing each vehicle was converted to permit operation on CNG.

Automotive Natural Gas Incorporated (ANGI) supplied and installed the CNG conversion kits. ANGI personnel made all initial CNG metering system adjustments. Adjustments were verified with a four gas infrared exhaust gas analyzer. On catalytic converter equipped vehicles, a tap was made ahead of the converter and air injection systems were overridden while adjustments were made to assure accurate engine out measurements of HC, CO, and oxygen. All emission control components and systems remained operational after the conversion to CNG. Following conversion the vehicles were again subjected to the aforementioned tests.

For the kits used in this study, operation on CNG requires that a mixer, which serves as a venturi, be installed between the carburetor and the air cleaner assembly. As air flow to the engine increases, the flow of CNG to the mixer and engine also increases. Since the mixer is installed in the normal air flow path, there exists the potential for an adverse effect on emissions when the vehicle is operated in the gasoline mode. In order to determine if the mixer had any effect during operation on gasoline another series of tests were conducted with this configuration. Upon completion of this series of tests, all CNG adjustments were sealed with epoxy and the vehicle received a final full power test on CNG.

BASELINE TESTING EMISSIONS RESULTS

The baseline testing confirmed that CNG has the potential to reduce some emissions but may cause increases in others. The initial data evaluation comparing averages from all initial Indolene and CNG tests resulted in the changes in emissions shown below.

TABLE 1: Changes in Emissions & Fuel Economy
CNG vs Indolene Before Kit Installed

Pollutant	% Change FTP	% Change HFET
Carbon Monoxide (CO)	-98.4	-97.8
Nitrogen Oxides (NO_x)	+ 7.9	-20.4
Total Hydrocarbons (THC)	+18.6	+31.9
Total Aldehydes	- 9.6	no data collected
Particulates	-53.7	no data collected
Carbon Dioxide (CO_2)	-25.6	-23.5
Fuel Economy (MPG)	+ 5.7	-11.5

The data shown in Table 1 suggest that for certain pollutants there is some degree of variation from one test type to the other. An initial examination of the test results for individual vehicles also indicates variations among vehicles. Following are more specific discussions of individual test results and their effects on each of the pollutants as well as on fuel economy and power.

CARBON MONOXIDE

Although initial CO levels and grams/mile reductions varied from vehicle to vehicle {C1, C2} (numbers in braces refer to figures in Appendix C), Figure 1 shows that in general, for both tests, CO levels decreased when the vehicles were operated on CNG but increased when they were operated on Indolene with the CNG kit installed. When operating on CNG, all vehicles showed reductions on both tests. Reductions ranged from 71.4 g/mi (97.0 percent) on the 1978 Chevrolet pickup (vehicle #2) and 22.7 g/mi (99.9 percent) on the 1984 Chevrolet van (vehicle #3) based on the FTP, to a 0.02 g/mi (50.0 percent) reduction on the 1986 Chevrolet pickup (vehicle #4) which was based on the HFET. As might be expected, the greatest absolute reductions occurred on the older, less controlled vehicles. The overall average decrease from the base case to CNG was 39.3 g/mi (98.4 percent) on the FTP and 20.4 g/mi (97.8 percent) on the HFET. When operating on Indolene after installation of the kit however, with just one exception, all vehicles showed increases in CO emissions from the base case. The increases ranged from 0.3 g/mi (1986 Chevrolet pickup - HFET) to 18 g/mi (1984 Chevrolet van - HFET). The one exception was the 1986 Chevrolet pickup which showed a 0.3 g/mi decrease on the FTP test only. On the average, CO emission increases were 7.8 g/mi (19.2 percent) on the FTP test and 10.0 g/mi (47.8 percent) on the HFET test with the kit installed.

CO reduction on CNG is greater during the first of the three phases of the Federal Test Procedure. This Cold Transient phase includes the start up of the cold engine where, for gasoline, excess liquid fuel is required to create a mixture rich enough to start and run the engine. This rich mixture results in very high HC and CO emissions during a cold start. Since CNG is already in a vapor state, such a large excess is not needed for starting and there is no unvaporized fuel passing through to the exhaust. Although there are still some quenching effects near cold surfaces, combustion is much more complete in a cold engine fueled by CNG. HC and CO emissions are reduced accordingly. This result is confirmed by the test data. Figure 2 shows that the reduction of CO emissions from Indolene without the kit installed to CNG for Phase 1 (Cold Transient) is much greater than the reduction for Phase 2 (Cold Stabilized) and is also greater than the reduction for Phase 3 (Hot Transient).

NO_X

It is more difficult to make general statements about changes in NO_X emissions {C3, C4}. Looking at Figure 3 however it can be seen that the average for vehicles #1 and #3 is higher for CNG - average 1.5 g/mi (115.5 percent) increase on FTP, 1.4 g/mi (91.3 percent) on HFET, but is lower on Indolene with the kit installed - average 0.1 g/mi (8.8 percent) decrease on FTP, 0.5 g/mi (28.9 percent) decrease on HFET {C5, C6}. The increase in NO_X for CNG is probably due, at least in part, to the fact that with the kit installed, manifold vacuum is applied to the vacuum advance unit. The greater initial spark advance minimizes hesitation on acceleration but tends to increase NO_X.

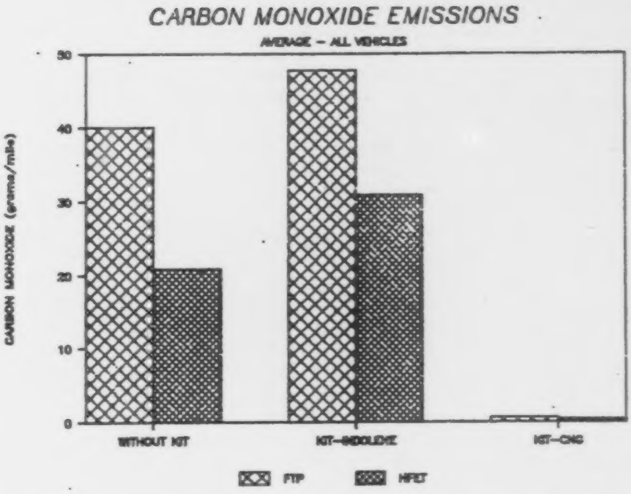

Figure 1: Average CO Emission Rates - FTP & HFET

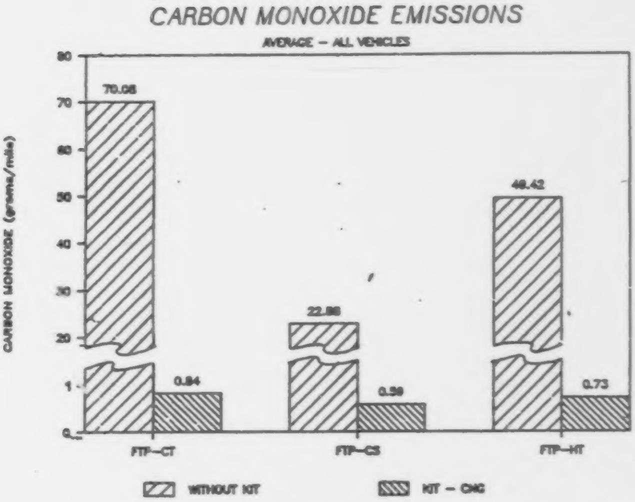

Figure 2: Average CO Emission Rates - Indolene Without Kit vs CNG

Figure 3 shows that for the earlier model year vehicle, 1978 Chevrolet pickup (vehicle #2), there was a relatively large decrease in NO_x emissions over the base case when operated on CNG - 2.2 g/mi (51.7 percent) on FTP, 3.9 g/mi (60.0 percent) on HFET, but a slight increase on Indolene after the kit was installed 0.06 g/mi (1.3 percent) on FTP, 0.14 g/mi (2.1 percent) on HFET. The decrease is probably due to the fact that this vehicle, having no air pump or catalytic converter, is basically uncontrolled and, as evidenced by the extremely low CO reading for CNG, is operating in a very lean condition. Figure 3 also shows that for vehicle #4 (1986 Chevrolet pickup) NO_x decreased 0.4 g/mi (18.4 percent) FTP and 1.4 g/mi (40.7 percent) HFET for Indolene with the kit installed. NO_x also decreased for CNG - 0.1 g/mi (4.3 percent) FTP and 1.7 g/mi (48.7 percent) HFET.

The changes in NO_x emissions were not consistent for CNG. Because there are only four vehicles in the study, the overall average for CNG is strongly influenced not only by the relatively large decrease from vehicle #2 but also by the increases from vehicles #1 and #3. As a result, it is not possible to make an accurate projection of NO_x emissions based upon this study alone. There is other data however which shows that two of the factors affecting NO_x emissions are air/fuel mixture ratios and ignition timing. It may be possible therefore, that adjustments to air/fuel mixture or spark advance calibrations might result in lower CNG NO_x emissions while still achieving CO reductions and acceptable driveability.

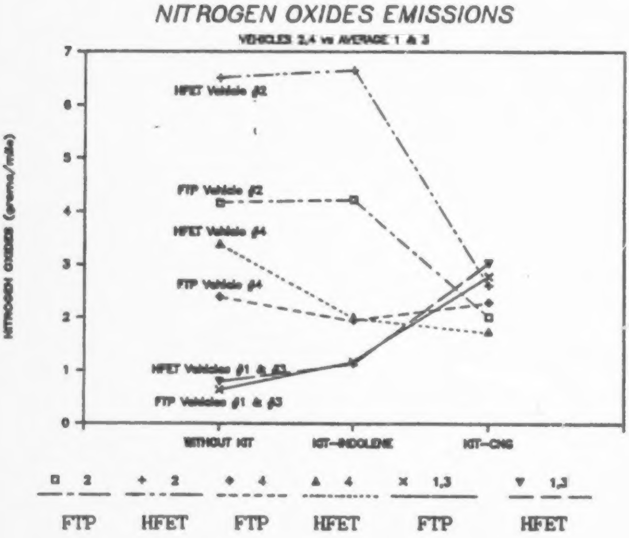

Figure 3: FTP and HFET NO_x Emissions Rates
Vehicles #2 and #4 vs Average for Vehicles #1 and #3

HYDROCARBONS

Initial HC emission levels and changes varied considerably from vehicle to vehicle and from test to test. On the average however, as can be seen from Figure 4, total HC emissions increased 0.4 g/mi (18.6 percent) on the FTP and 0.3 g/mi (31.9 percent) on the HFET for operation on CNG and increased 0.4 g/mi (16.9 percent) on the FTP and 0.1 g/mi (11.6 percent) on the HFET for operation on Indolene.

Examining the results for individual vehicles (C5, C6) it can be seen that for the two newest technology vehicles (#3 and #4), average HC emissions increased on Indolene fuel with installation of the kit - 0.2 g/mi (32.3 percent) on the FTP and 0.1 g/mi (73.1 percent) on the HFET. On CNG these vehicles showed larger average increases over the base case - 1.7 g/mi (248 percent) on FTP, 1.0 g/mi (758 percent) on HFET. The higher Indolene emissions may be due to the air flow disruption of the kit's mixer while the increased CNG emissions may be partially due to the limited ability of catalytic converters to oxidize methane as was reported in a previous study [3]. By comparison, emissions from the essentially uncontrolled 1978 Chevrolet pickup (vehicle #2) for Indolene with the kit were 0.3 g/mi (8.7 percent) higher on the average for the two tests but were 1.6 g/mi (51.6 percent) lower for CNG. The reduced CNG levels may be due to the lean CNG mixture. Although equipped with a catalytic converter, the 1981 Ford van (vehicle #1) showed tendencies more like the uncontrolled 1978 Chevrolet pickup (vehicle #2) in that CNG emissions were not increased as much as they were for the newer vehicles - 0.2 g/mi (5.2 percent) increase on the FTP, 0.5 g/mi (51.6 percent) on the HFET, and Indolene emissions with the kit were only a little higher - 0.7 g/mi (21.6 percent) on the FTP and were slightly reduced - 0.02 g/mi (2.2 percent) on the HFET. These tendencies may be accounted for in part by the fact that the vehicle has a very low ratio differential and under the higher engine loads of the FTP it was probably operating in the power circuit of the carburetor a large portion of the time. This would cause an oxygen poor condition which would result in reduced converter efficiency. The vehicle would thus act more like an uncontrolled vehicle and exhibit higher HC emissions when operating on Indolene but show a smaller increase in HC with the leaner CNG mixture. CO levels for this vehicle corroborate the lean CNG condition.

The reduction in total hydrocarbon emissions from CNG varies from phase to phase in the FTP in very much the same way that the carbon monoxide reduction does. From Figure 5 it can be seen that, as was the case for CO, the greatest Total HC reduction occurs during phase 1 (Cold Transient) with a smaller reduction during phase 3 (Hot Transient). This too is probably due to the fact that excess fuel is not required during cold start-up when operating on CNG. Total hydrocarbons increased during phase 2 (Cold Stabilized) where CO showed the smallest decrease.

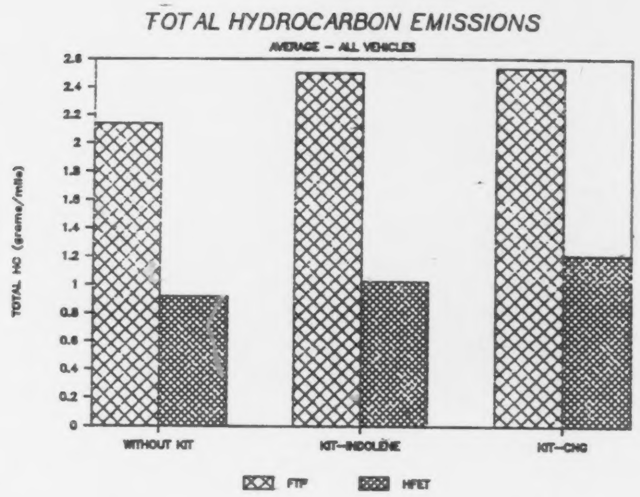

Figure 4: Average Total HC Emission Rates - FTP & HFET

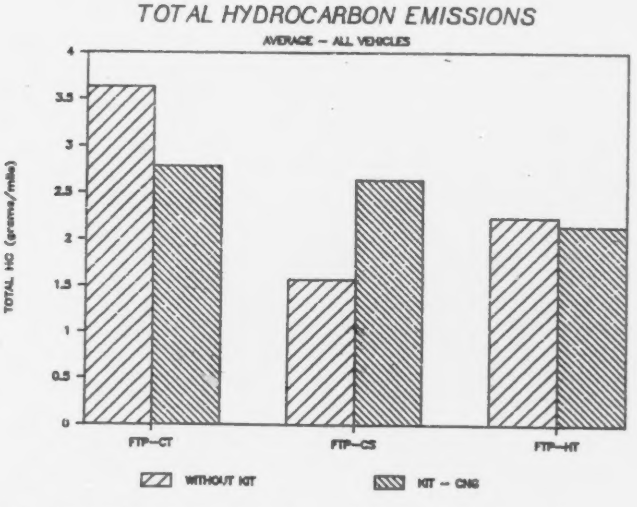

Figure 5: Average Total HC Rates - Indolene Without Kit vs CNG

When evaluating hydrocarbon emissions, particularly for a fuel such as CNG, in addition to determining total unburned hydrocarbon emission levels, the relative proportions of reactive and non-reactive hydrocarbons should also be examined. Other studies [1, 2] have shown that the predominant unburned hydrocarbon in the exhaust from CNG fueled vehicles is methane which is a photochemically non reactive gas. At this time however there is not an agreed upon procédure for determining non methane hydrocarbon levels that takes into account all of the factors affecting non methane analysis. The Society of Automotive Engineers recommended practice J1151 June 83 specifies that dilute exhaust samples be collected from each bag of the FTP test. These samples are analyzed for methane using a gas chromatograph (GC). The methane concentrations are then subtracted from the total hydrocarbon concentrations as determined in accordance with the Federal Test Procedure (FTP) defined in CFR 40, Part 86 [9]. As written, this procedure does not take into account the fact that the Flame Ionization Detector (FID) used to measure HC concentrations is calibrated on propane. Other studies [7] have found that a FID calibrated on propane can read 10 percent to 20 percent higher for methane than for an equivalent concentration of propane. Since the non methane value is the difference between the FID reading for total hydrocarbons and the GC reading for methane, the error in the non methane value compared to the error in the total HC reading is proportional to the ratio of total HC to non methane HC. The non methane error can therefore be as much as four or five times as great as the total HC error. Also unaccounted for in the SAE procedure is the difference in densities of CNG HC emissions compared to Indolene HC emissions. This difference can be as great as 15 percent. In an EPA study [7] Robert Bruetsch compared four different methods for calculating non methane HC. The methods ranged from no corrections to correcting for FID calibration, exhaust HC density and calculating non methane HC from the NMHC fuel fraction rather than by subtracting methane. There was a difference in the NMHC results for each method. The Colorado Department of Health is currently studying the methods used for calculating non methane HC. Although specific results have varied, in general, methane has been found to be the major hydrocarbon component of CNG exhaust and non methane HC is expected to be 30 percent to 70 percent lower for CNG than it is for gasoline.

ALDEHYDES

Another set of factors contributing to the reactivity of exhaust emissions are aldehydes. Aldehyde emission levels were not obtained for operation on Indolene after installation of the kit but total aldehyde, formaldehyde, acetaldehyde and acrolein levels for Indolene operation before installation of the CNG kit and for CNG operation after installation were determined and are shown in Figure 6 {C7}. (Portions of the original baseline test - Indolene, without kit - for vehicle #3 were not usable so the affected parts of that test were repeated. The original formaldehyde data however was not affected. Since the increase in formaldehyde for vehicle #3 operating on CNG using the original base case data is very nearly the same as the average increase for the other three vehicles - 58.7 percent vs 60.6 percent respectively - the original base case formaldehyde data has been included in this report.) The average total aldehyde level decreased 2.8 mg/mi or 9.6 percent and the average formaldehyde level increased 8.4 mg/mi or 60.4 percent. The average acetaldehyde level decreased 0.9 mg/mi (30.0 percent) while the average acrolein level decreased 0.8 mg/mi (67.4 percent) over the base case for CNG.

The presence of low molecular weight hydrocarbons (CH_4) in a lean (oxygen rich) environment probably favors formation of simpler aldehydes such as formaldehyde (HCHO).

Although some aldehyde emissions increased for CNG operation, a previous study [2] has indicated that their contribution to total exhaust reactivity might be comparable to the hydrocarbon contribution. In an initial effort to estimate the difference in total reactivity between gasoline and CNG exhausts, a modified version of the approach used by Fleming and Allsup [2] was employed (see Appendix B). The result of this estimate indicates that the total exhaust reactivity from natural gas is approximately 25 percent of the total reactivity from gasoline. This result is consistent with the estimate by Fleming and Allsup that for CNG, aldehyde reactivity is roughly equivalent to hydrocarbon reactivity and consistent with preliminary CDH results showing CNG non-methane hydrocarbons to be about 16 percent of gasoline non-methane HC's. This result also agrees with the study by McJones and Corbeil [1] which reported average hydrocarbon reactivities for CNG that were between 11 percent and 32 percent of the HC reactivity for gasoline.

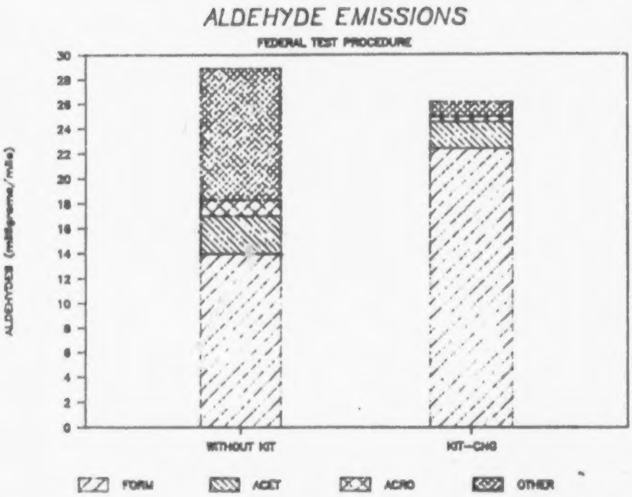

Figure 6: Average FTP Aldehyde Emission Rates - Indolene Without Kit, CNG

PARTICULATES

Figure 7 shows that average particulate emissions decreased for operation on gasoline with the kit installed - 2.0 mg/mi (5.4 percent) (C8). For CNG operation however, particulate emissions were much lower than for the base case. In fact, according to a study by the Colorado Department of Health [1], particulate readings for both newer technology vehicles (#3 and #4) regardless of fuel or CNG modification as well as for all vehicles when operating on CNG are in the range of background levels. For this reason the 19.9 mg/mi (53.7 percent) reduction which was observed may not be accurate but some reduction in particulates when using CNG is expected. Important sources of particulate emissions from gasoline fueled engines are the larger molecules of aromatic hydrocarbons typically found in gasoline [6]. The CNG used in this study consists of approximately 82 percent methane, 6.5 percent ethane and 1.5 percent propane and higher level hydrocarbons [7]. The remaining 10 percent is primarily nitrogen, oxygen and carbon dioxide. There are virtually no aromatic hydrocarbons. This lack of larger aromatic hydrocarbon molecules would be expected to result in reduced particulate emissions.

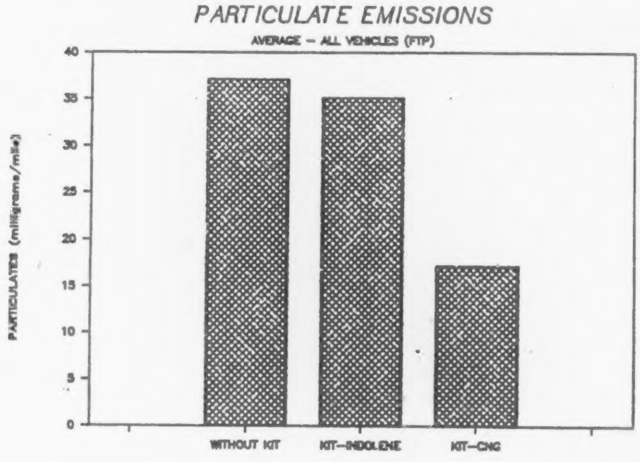

Figure 7: Average FTP Particulate Emission Rates

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[1] A study of background particulate readings conducted by the Colorado Department of Health in July and August 1988 which consisted of 12 FTP tests with no exhaust samples introduced indicated that particulate levels below 52.5 mg/phase (roughly 15 mg/mi) were statistically indistinguishable from background readings at a 97.5 percent confidence level.

CARBON DIOXIDE

In addition to the effects CNG has on emissions traditionally considered as pollutants, its effects on CO_2 were also examined. The primary constituent of CNG is methane. Due to methane's relatively low ratio of carbon atoms to hydrogen atoms [2] it is reasonable to expect a reduction in CO_2 emissions as well as in CO emissions. The results of this study confirm that expectation. Figure 8 shows that CO_2, like CO, decreased when vehicles were operated on CNG (C9, C10) - average 154.5 g/mi (25.6 percent) on the FTP and 111.5 g/mi (23.5 percent) on the HFET. When vehicles with kits installed were operated on Indolene however, CO_2 emissions increased by a much smaller amount - average 10.3 g/mi (1.7 percent) FTP, 3.0 g/mi (0.6 percent) HFET.

While CO_2 emissions are important for the impact they may have on the "greenhouse effect", methane has also been considered as a possible contributor to that phenomenon. At this time the relative importance of each of these components is not known but the increase in methane from CNG is on the order of 2 g/mi [3] while the decrease in CO_2 averages 155 g/mi.

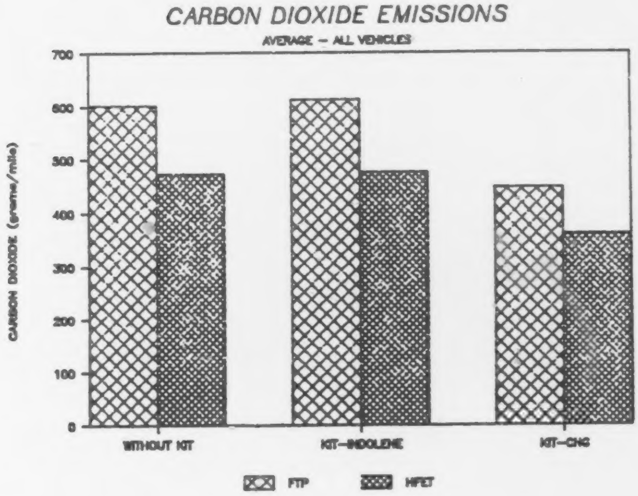

Figure 8: Average Carbon Dioxide Emission Rates - FTP & HFET

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[2] For methane (CH_4) C:H = 1:4 = 0.25, for octane (C_8H_{18}) C:H = 8:18 = 0.44.

[3] For Indolene, methane levels are nearly zero; for CNG, methane is approximately equal to total HC (average 2.53 g/mi FTP) minus non-methane HC (average 0.35 g/mi FTP) = 2.19 g/mi.

FUEL ECONOMY

Since the FTP and HFET tests were originally designed to measure fuel economy under very different operating conditions, it is not too surprising to find that the effects of CNG on fuel economy were different for the two tests - see Figure 9. Within each test type however, all four vehicles showed similar trends when the kit was installed and also when the vehicles were operated on CNG (C11, C12). On the FTP test, installation of the kit caused a decrease of 0.5 miles per gallon (3.4 percent) and operation on CNG resulted in an increase in fuel economy of 0.8 mpg (5.7 percent). On the HFET, fuel economy decreased 0.6 mpg (3.3 percent) when the kit was installed but unlike the FTP, highway fuel economy also decreased - 2.0 mpg (11.5 percent) when the vehicles were switched to CNG.

Since the two tests showed opposite changes for operation on CNG it should be expected that typical changes in fuel economy would be somewhere between these limits. Vehicles operated more on the highway under steady state conditions might experience a reduction in fuel economy, whereas vehicles operated more in a stop and start urban mode should see either less of a reduction or an improvement in fuel economy. Also, there is a certain amount of confusion introduced when attempting to compare volume measurements of a gaseous fuel such as CNG to gallons of liquid gasoline. Public Service Company uses an empirically derived mileage performance conversion for measuring CNG dispensed as a vehicle fuel [5]. Under this conversion, 128 cubic feet of CNG (108 ft^3 at standard temperature and pressure) supply the equivalent mileage of one gallon of gasoline and are therefore considered as one gallon of CNG. The conversion factor used by the Colorado Department of Health for this study is based upon a specific gravity of 0.6565 for liquid natural gas. The two conversions differ slightly but can be compared on the basis of mass densities (pounds per gallon). Public Service's conversion gives a density of 5.54 lb/gal (108 ft^3 std/gal * 0.0512952 lb/ft^3 std) whereas the CDH conversion gives a value of 5.47 lb/gal (8.33 lb/gal H_2O x 0.6565). The difference (1.3 percent) is so small that it can be ignored for most purposes.

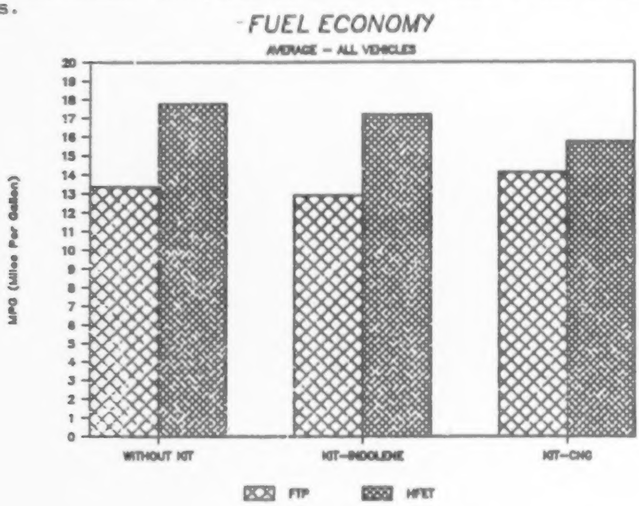

Figure 9: Average Fuel Economy - FTP & HFET

POWER

Both horsepower and torque showed consistent reductions for all four vehicles when operated on CNG. Figures 10 and 11 show that the reductions for horsepower and torque at a given engine speed ranged from about 15 percent to 25 percent at low speeds (2100 rpm) up to about 20 percent to 33 percent at higher engine speeds (3400 rpm). The average reduction in peak horsepower from Indolene to CNG was 22.5 horsepower (24.3 percent). The average reduction in peak torque was 457 foot-pounds (22.5 percent). For two of the vehicles (#1 and #3) (C13, through C16) the horsepower on CNG peaked at lower engine speeds (2700 rpm and 3400 rpm respectively) then dropped off sharply over the next 100 rpm increase. This may have been the result of an excessively lean air/fuel mixture. Peak CNG horsepower for vehicles #2 and #4 seemed to occur at the same or a higher rpm than it did for Indolene. For three vehicles (#1, #3, and #4) (C17 through C20) peak CNG torque occurred at lower speeds. (Vehicles #1 and #3 showed sharp drops in torque at 2700 rpm and 3400 rpm respectively like they did for horsepower.) The peak torque for vehicle #2 on CNG appears to have occurred at the same or a higher rpm than it did for Indolene. This reduction in power may be attributable to two causes. First, since CNG is already in a vapor state when it enters the mixer it occupies a significant portion of the total volume of the air/fuel mixture - approximately ten percent [1]. The available energy in each cylinder charge is thereby reduced resulting in a corresponding decrease in horsepower. The second cause is a direct result of the need to compromise on optimal ignition timing in order to accommodate the slower flame speed of CNG and the conscious effort to set timing so as to minimize emissions rather than to maximize power.

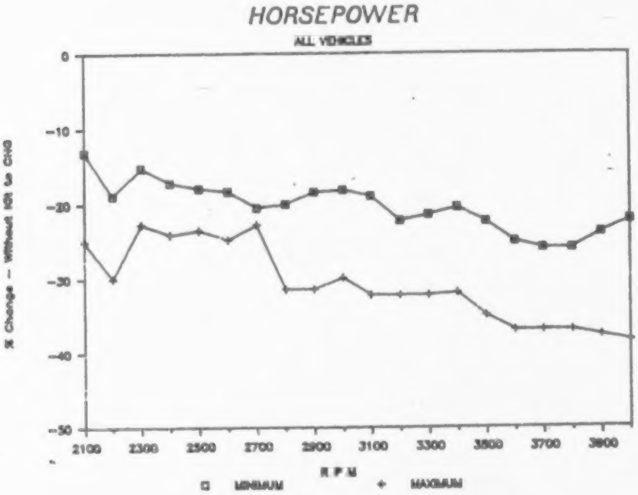

Figure 10: Minimum, Maximum Change in Horsepower - Indolene Without Kit to CNG

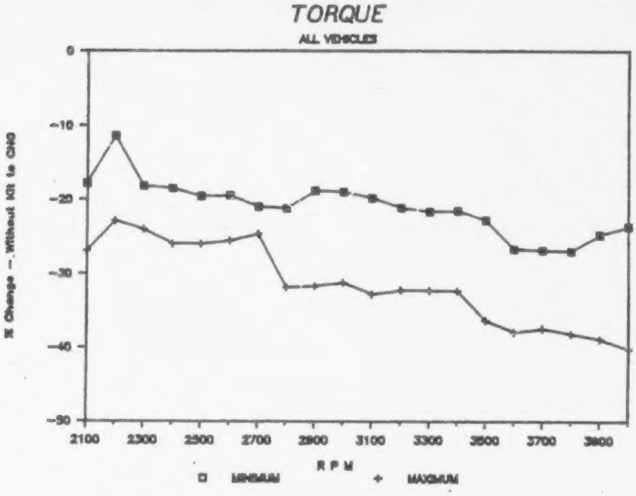

Figure 11: Minimum, Maximum Change in Torque - Indolene Without Kit to CNG

SUMMARY

Figures 12 and 13 summarize the changes in emissions, power, and fuel economy for the tested fleet. As Figure 12 shows, when the vehicles were operated on Indolene (or gasoline) with the kit installed CO, HC, and CO_2 emissions increased while NO_x, Particulates, and Fuel Economy decreased. (Aldehydes and power were not measured for Indolene with the kit installed.) Figure 13 shows that when operated on CNG, the test fleet had large reductions in CO, non methane hydrocarbons, acrolein and particulates as well as smaller reductions in acetaldehyde and CO_2. It should also be noted that total hydrocarbons (consisting primarily of methane) increased as did total aldehydes and formaldehyde while peak horsepower and torque were reduced. NO_x emissions increased for two of the four vehicles tested, decreased for one and were about the same or slightly lower for the last. By themselves these mixed results are inconclusive but other information suggests that lower CNG NO_x emissions may be attainable through alteration of certain engine parameter settings. Fuel economy results were also mixed but seemed to be correlated to driving conditions i.e. relatively unchanged or increased economy for city driving but decreased economy for highway driving.

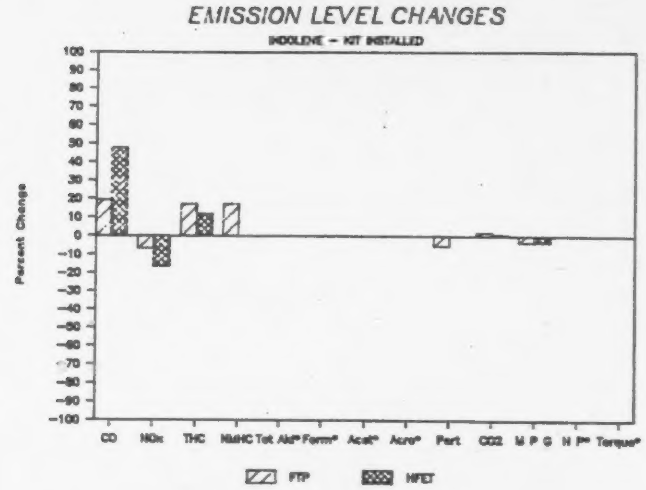

Figure 12: Changes in Average Emissions, Fuel Economy, & Power - Indolene Without Kit to Indolene With Kit - FTP & HFET

* Indolene Without Kit values were not obtained for these factors.

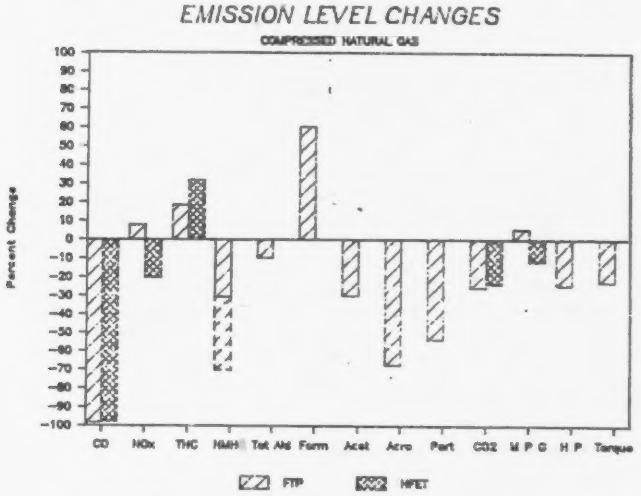

Figure 13: Changes in Average Emissions, Fuel Economy, & Power - Indolene Without Kit to CNG - FTP & HFET

CONCLUSIONS

As with many other strategies, the use of CNG involves some trade offs and compromises. As long as CNG refueling stations are not prevalent, vehicles which are not in a locally operating fleet will need to retain the capability to operate on gasoline as well as on CNG. This dual fuel capability requires compromises in engine parameter settings such as spark timing and air fuel mixture and results in somewhat less than optimum performance on either fuel. Also, in order to maximize benefits in areas such as HC and CO emissions, fuel economy and power may be compromised.

In spite of these compromises, CNG shows a potential for reducing CO, CO_2, particulate and reactive hydrocarbon emissions, all of which are of particular concern in high altitude areas such as Denver. There are also potential problems which must be considered. These include increases in methane and formaldehyde emissions as well as possible increases in NO_x emissions for CNG operation and increases in CO and both total and non-methane hydrocarbon emissions when converted vehicles are operated on gasoline.

Because there are increases in both non-methane HC and CO emissions when dual fuel vehicles are operated on gasoline but there are corresponding decreases on CNG which can be as great as 92 to 98 percent, minimizing gasoline operation should enhance CO and reactive HC emissions benefits. As an example of the relative CO benefit of using CNG, this study found that the average non converted vehicle emits 30.48 grams of CO per mile. The average converted vehicle emits 0.55 g/mi CO when operated on CNG but 39.33 g/mi on gasoline. Therefore, an average converted vehicle can be driven 71.5 miles on CNG before it emits as much CO as it would driving one mile on gasoline (71.5 * 0.55 < 1 * 39.33) (C21). Looking at the same data another way however, compared to an non converted vehicle, the average converted vehicle "saves" 29.93 g/mi CO (30.48 g/mi - 0.55 g/mi) when operated on CNG but emits an "extra" 8.85 g/mi (39.33 g/mi - 30.48 g/mi) on gasoline (C22). If at least 23 percent of the miles driven by a converted vehicle are on CNG, the CO emissions "saved" could exceed the "extra" CO emissions due to operating on gasoline for the remaining miles (.23 * 29.93 > .77 * 8.85). However, this "break even" condition would only apply under ideal circumstances where all conversions achieve reductions as large as those achieved by these carefully set up test vehicles and are maintained for as long as the converted vehicles are in use. In reality, not all conversions will be perfect. Misadjustment, both on initial installation and during in-use as well as system deterioration over time must be allowed for. Also, the objective of CNG conversion is not to "break even" but to reduce CO emissions. An effective CNG conversion program should therefore be designed not only to encourage maximum CNG operation but also to discourage or even limit gasoline operation to a portion much less than 77 percent. Policies such as limiting on-board gasoline capacity and or supporting favorable CNG to gasoline cost of operation ratios should contribute directly to CO reduction.

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2. R.D. Fleming and J.R. Allsup, "Emission Characteristics of Natural Gas as an Automotive Fuel." Paper 710833 presented at SAE National Combined Fuels and Lubricants, Powerplant and Truck Meetings, Saint Louis, October 1971.

3. Physical Technology Division of B. C. Research, "Exhaust Emission Measurements of Natural GAs Fueled Vehicles." Paper prepared for Energy, Mines, and Resources Transportation, Energy Division, Ottawa, Ontario, January 1986.

4. National Institute of Petroleum Energy Resources - telephone conversation September 13, 1988 with J.R. Allsup.

5. Public Service Company of Colorado - telephone conversations September 2, 1988 with Gary Dykman, September 7, 1988 with Mark Hennesy.

6. J.M. Lang, L. Snow, R. Carlson, F. Black, R. Zweidinger, S. Tejada, "Characterization of Particulate Emissions from In-Use Gasoline-Fueled Motor Vehicles", SAE Paper 811186, 1981.

7. Public Service Company of Colorado, "Table of Mole Percent Concentrations for 1983, 1984, and 1985", furnished by Mark Hennesy.

8. Robert I. Bruetsch, "Emissions, Fuel Economy, and Performance of Light-Duty CNG and Dual-Fuel Vehicles, Technical report EPA/AA/CTAB-88-05 submitted June 1988.

APPENDIX A

TEST VEHICLE DESCRIPTION

APPENDIX A

Veh. No.	Model Year	Make	Model	Veh. Class	GVW	Engine Size	Emission Control Configuration*
#1	1981	Ford	Van	LDT	5900	5.0 l (302 cid V8)	EGR/AIR/OC
#2	1978	Chev	Pickup	HDT	8200	5.7 l (350 cid V8)	PCV
#3	1984	Chev	Van	LDT	6000	5.0 l (305 cid V6)	EGR/AIR/OC
#4	1986	Chev	Pickup	LDT	4900	4.3 l (262 cid V6)	EGR/AIR/OC

* EGR - Exhaust Gas Recirculation
AIR - Air Injection
OC - Oxidation Catalyst
PCV - Positive Crankcase Ventilation

APPENDIX B

REACTIVITY CALCULATION

APPENDIX B

Fleming and Allsup [2] used the following formulas to calculate reactivity in terms of ethylene emission rates:

$$R_{H,A} = (r_{H,A} * M_{ETH} * m_{H,A})/M_{H,A}$$

Where:

$R_{H,A}$=Reactivity of the hydrocarbon (H) or aldehyde (A) exhaust component expressed in terms of ethylene emission rates;

$r_{H,A}$=Molar rate-of-NO_2-formation reactivity of the hydrocarbon or aldehyde exhaust component relative to the molar reactivity of ethylene;

$M_{ETH,H,A}$=Average molecular weight of ethylene, exhaust hydrocarbons or exhaust aldehydes;

$M_{H,A}$=Mass rate of emissions of exhaust hydrocarbons or aldehydes.

The modifications employed by CDH after conferring with Mr. Allsup [4] were based upon the following assumptions:

1) The typical composition and therefore the average molecular weights of exhaust hydrocarbons and aldehydes ($M_{H,A}$) are relatively independent of their respective emission rates,

2) The molar reactivities ($r_{H,A}$) are likewise relatively independent of emission rates,

3) The molar reactivity factor ($r_{H,A} * M_{ETH}/M_{H,A}$) is therefore also relatively independent of emission rates and for a particular exhaust and a particular fuel can be considered a constant ($KH,A=rH,A * M_{ETH}/M_{H,A}$) for fuel type I (Indolene/gasoline) or fuel type N (CNG),

4) The ratio of the reactivity of aldehydes (R_{AI}) to the reactivity of hydrocarbons (R_HI) is approximately the same for the gasoline used by Fleming and Allsup as it is for the Indolene used by CDH (R_{AI}/R_{HI} [F&A] = R_{A_I}/R_{H_I} [CDH],

5) The ratio of the reactivity of aldehydes (R_{AN} to the reactivity of hydrocarbons (R_{HN}) is approximately the same for the natural gas used in each study (R_{A_N}/R_{H_N} [F&A] = R_{A_N}/R_{H_N} [CDH]), and

6) The ratio of the hydrocarbon reactivity factor for CNG (K_{H_N}) to the hydrocarbon reactivity factor for gasoline (K_{H_I}) is approximately the same for both studies (K_{H_N}/K_{H_I} [F&A] = K_{H_N}/K_{H_I} [CDH]) and is approximately equal to one.

The ratio of the total reactivity of the exhaust from CNG to the total reactivity of the exhaust from gasoline can be expressed as:

$$R_N/R_I = (R_{H_N} + R_{A_N})/(R_{H_I} + R_{A_I})$$

dividing the numerator and denominator by R_{I_H} gives:

$$R_N/R_I = (R_{H_N}/R_{H_I} + R_{A_N}/R_{H_I})/(R_{H_I}/R_{H_I} + R_{A_I}/R_{H_I})$$

$$= (R_{H_N}/R_{H_I} + R_{A_N}/R_{H_N} \ast R_{H_N}/R_{H_I})/(1 + R_{A_I}/R_{H_I}).$$

Using the reactivities reported by Fleming and Allsup and the mass emissions rates from the CDH study:

$$R_{H_N}/R_{H_I} = (K_{H_N}/K_{H_I}) \ast (m_{H_I}/m_{H_N}) = 1 \ast 0.346/2.138 = 0.162$$

$$R_{A_N}/R_{H_N} = 0.088/0.073 = 1.205 \text{ at Air Fuel Equivalence Ratio} = 1.2$$

$$(= 0.068/0.092 = 0.739 \text{ at AFER} = 1.0)$$

$$R_{A_I}/R_{H_I} = 0.18/0.46 = 0.391 \text{ at AFER} = 1.2$$

$$(= 0.09/0.63 = 0.143 \text{ at AFER} = 1.0)$$

which yields:

$$R_N/R_I = 0.257 \text{ at AFER} = 1.2 \ (0.246 \text{ at AFER} = 1.0).$$

APPENDIX C

COMPARISON OF TEST RESULTS FOR INDIVIDUAL VEHICLES AND TOTAL CO EMISSIONS WITH KIT INSTALLED, GASOLINE VS CNG

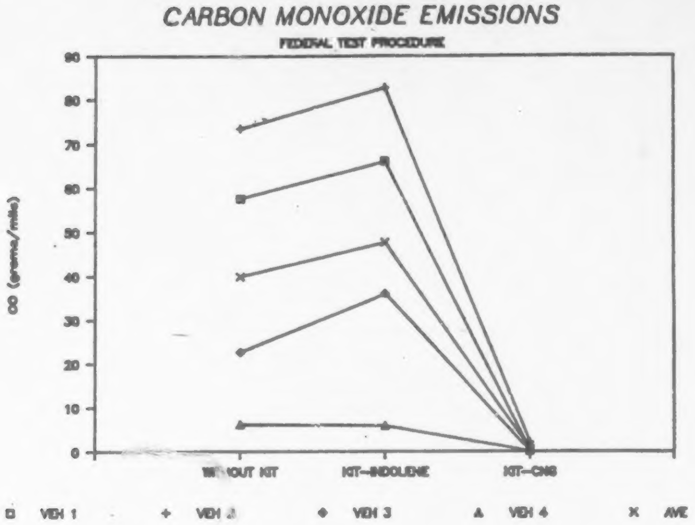

Figure C1: FTP CO Emission Rates - Four Vehicles

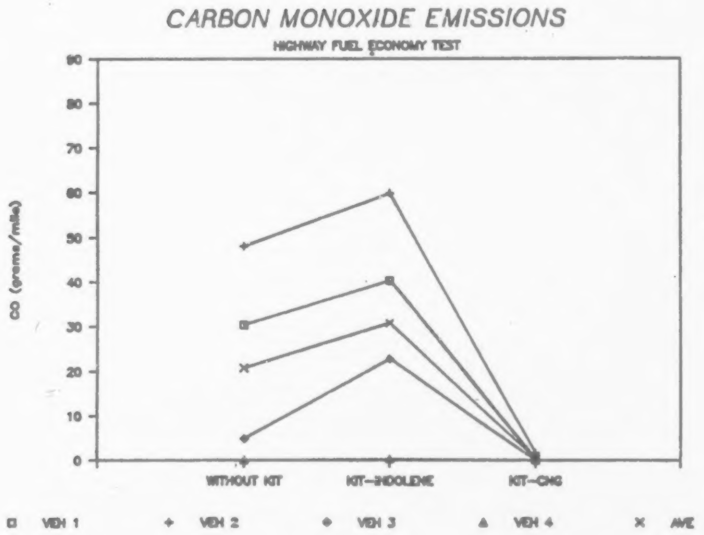

Figure C2: HFET CO Emission Rates - Four Vehicles

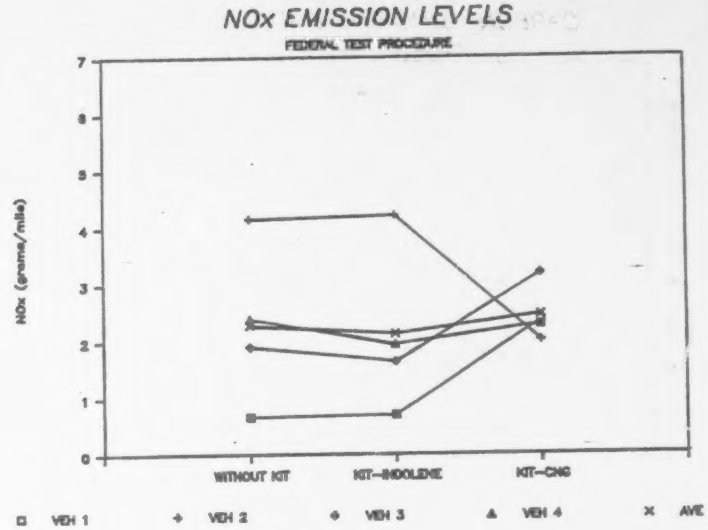

Figure C3: FTP NO_x Emission Rates - Four Vehicles

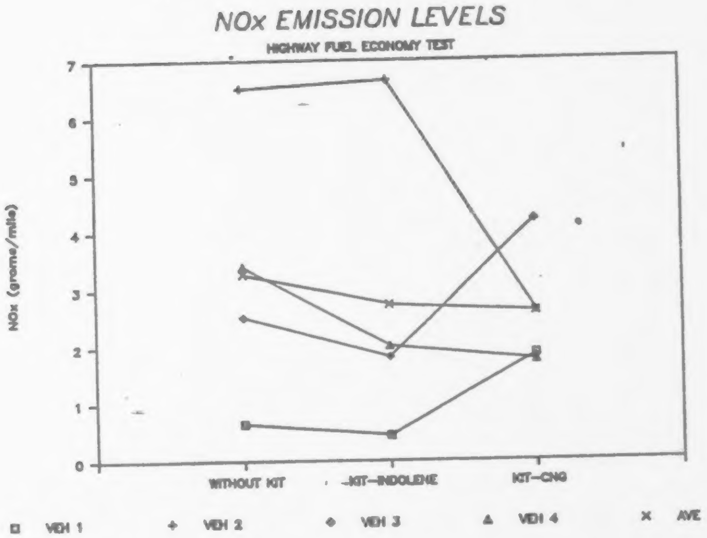

Figure C4: HFET NO_x Emission Rates - Four Vehicles

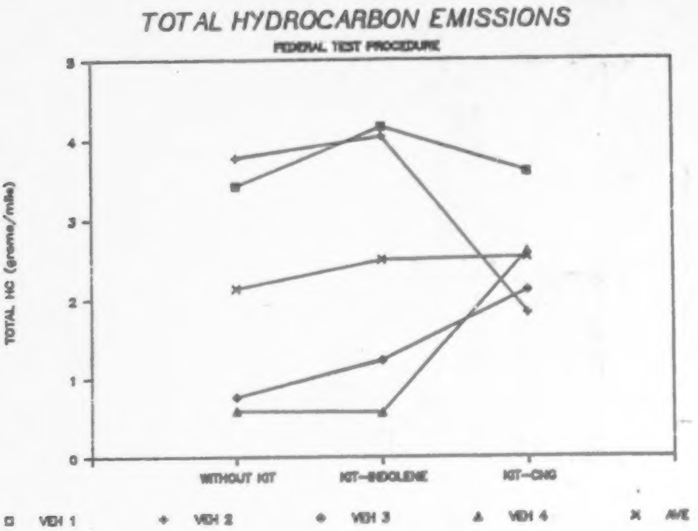

Figure C5: FTP Total HC Emission Rates - Four Vehicles

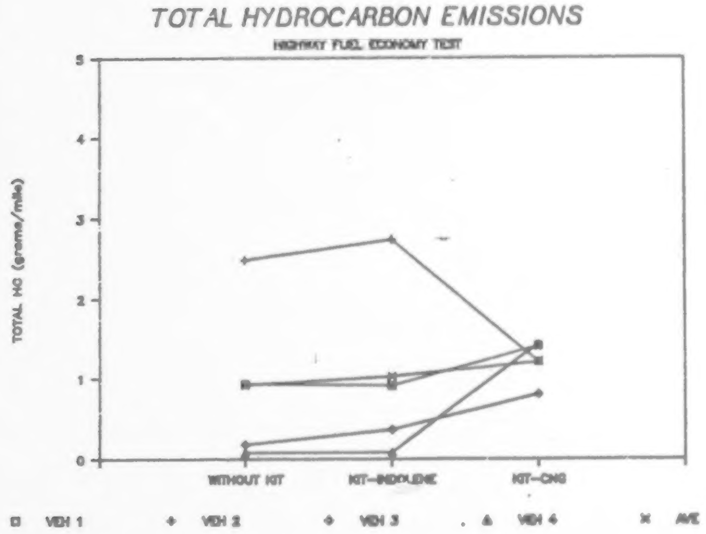

Figure C6: HFET Total HC Emission Rates - Four Vehicles

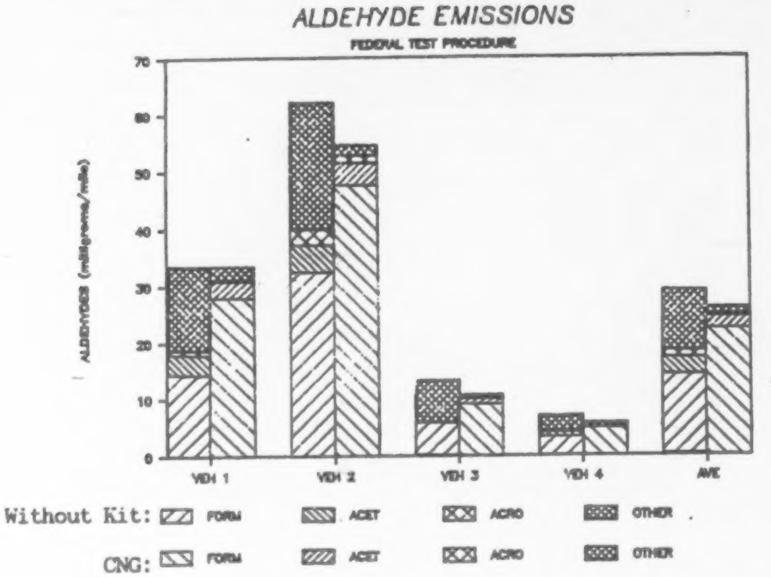

Figure C7: FTP Aldehyde Emission Rates - Four Vehicles & Their Average

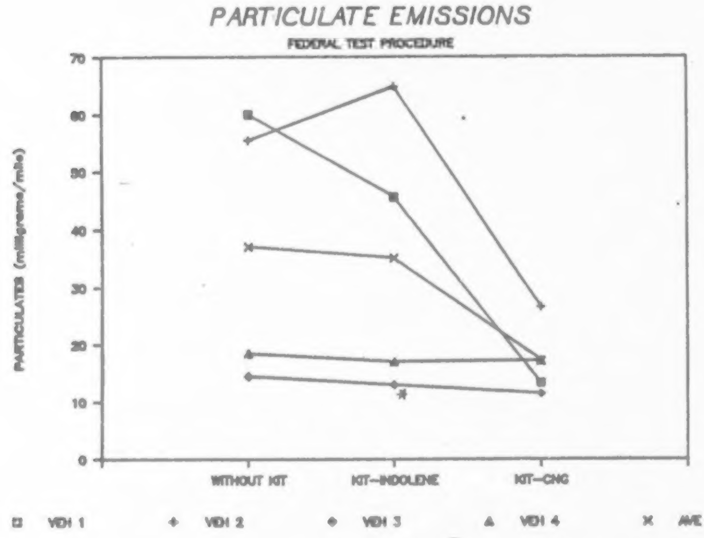

Figure C8: FTP Particulate Emission Rates - Four Vehicles

* Data for vehicle #3 (1984 Chevrolet van) operating on Indolene with the kit installed was not available but it can be assumed that this vehicle would perform similarly to the other late model LDT. Accordingly, the "Indolene with kit" value was estimated at midway between the "Without kit" and "CNG" values.

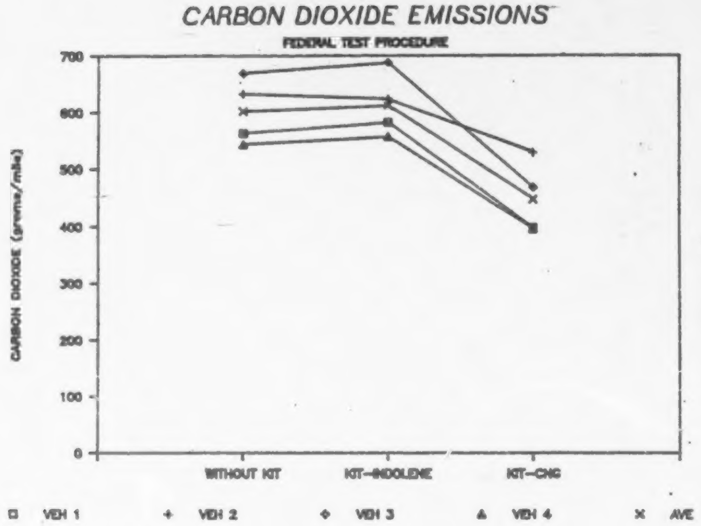

Figure C9: FTP CO_2 Emission Rates - Four Vehicles

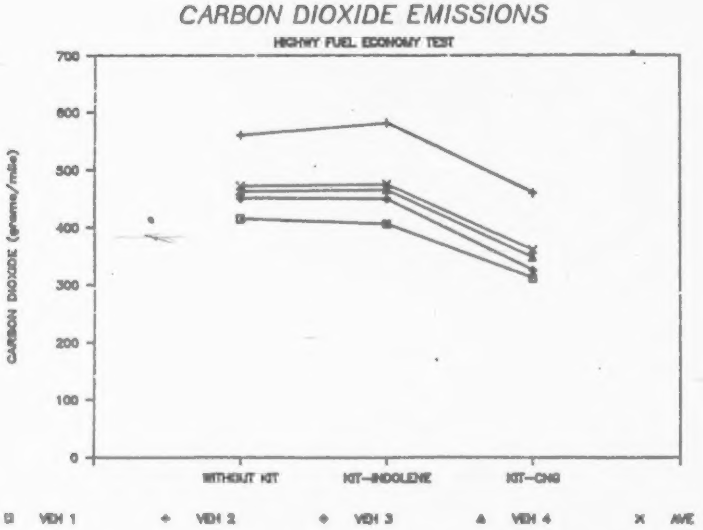

Figure C10: HFET CO_2 Emission Rates - Four Vehicles

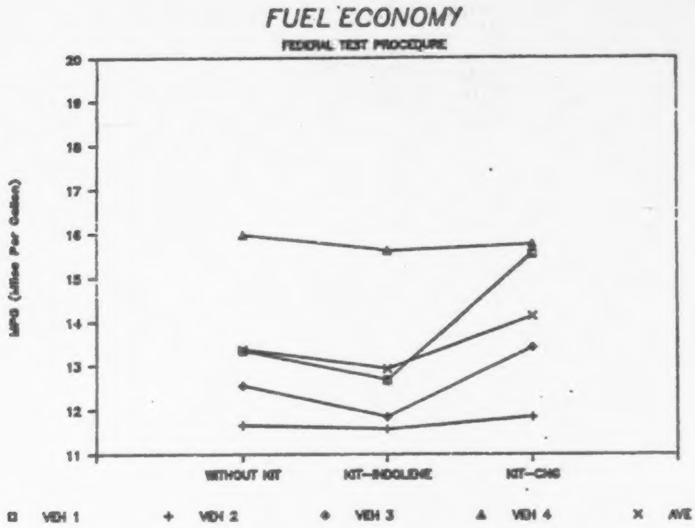

Figure C11: FTP Fuel Economy - Four Vehicles

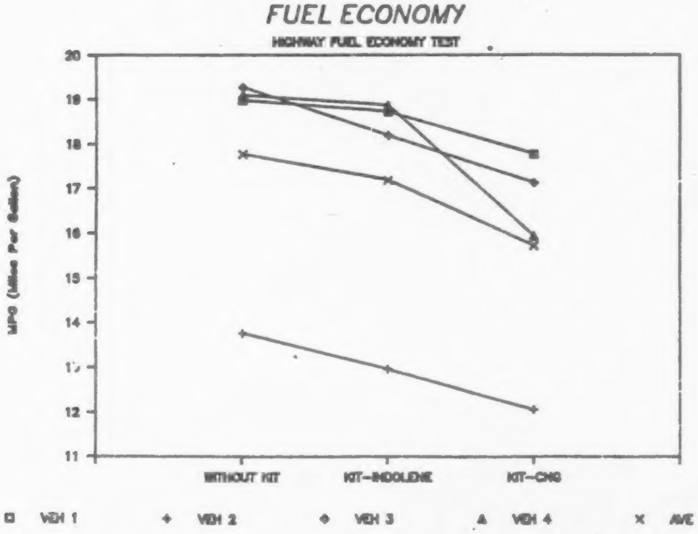

Figure C12: HFET Fuel Economy - Four Vehicles

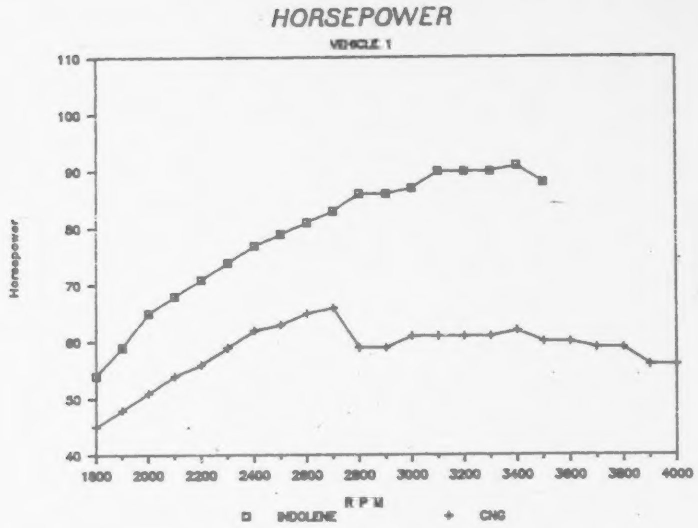

Figure C13: Horsepower - Indolene Without Kit vs CNG - Vehicle #1

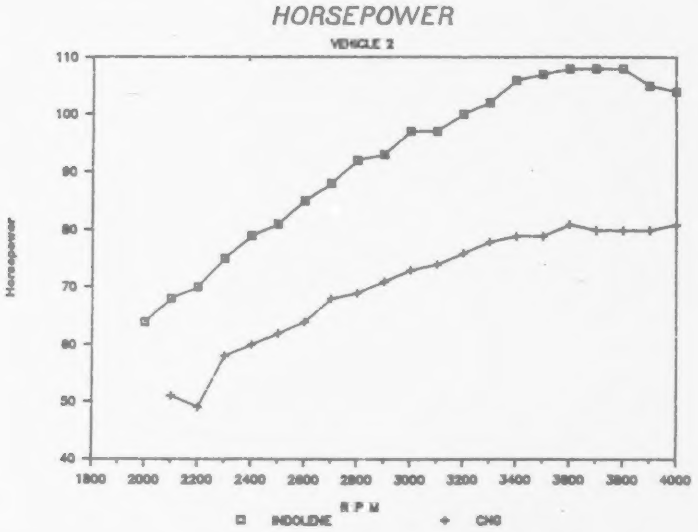

Figure C14: Horsepower - Indolene Without Kit vs CNG - Vehicle #2

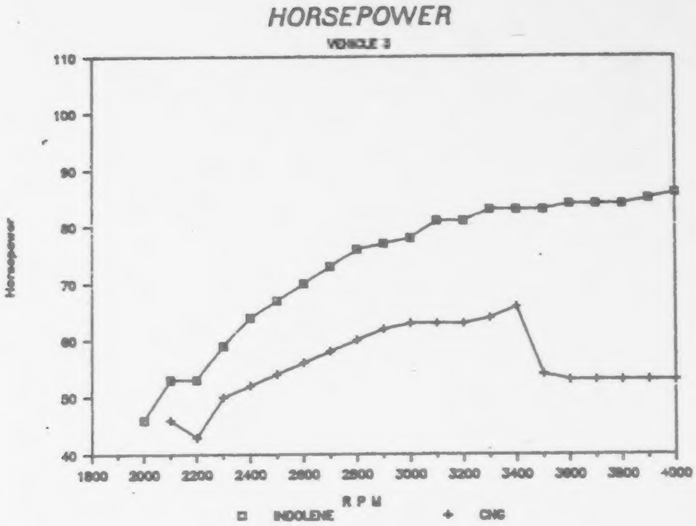

Figure C15: Horsepower - Indolene Without Kit vs CNG - Vehicle #3

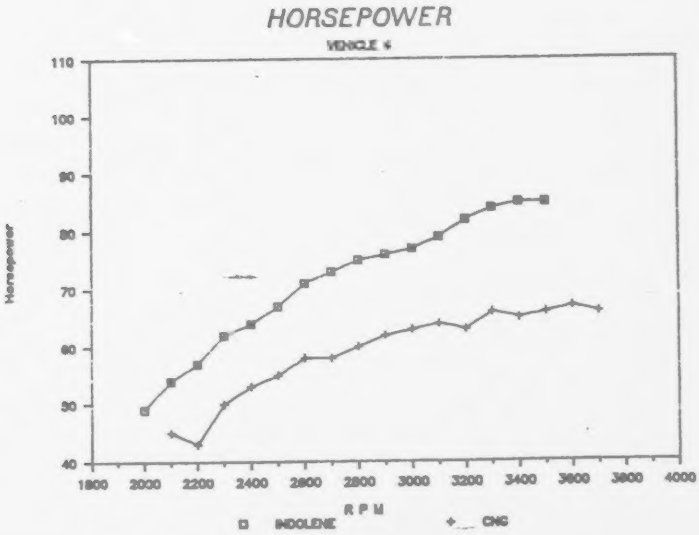

Figure C16: Horsepower - Indolene Without Kit vs CNG - Vehicle #4

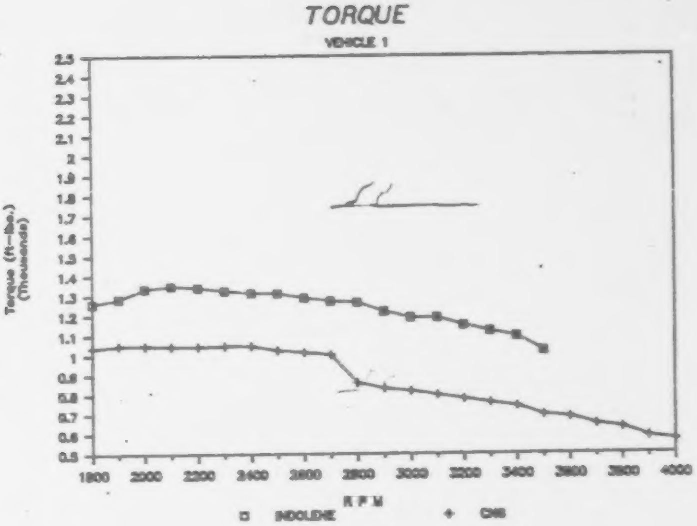

Figure C17: Torque - Indolene Without Kit vs CNG - Vehicle #1

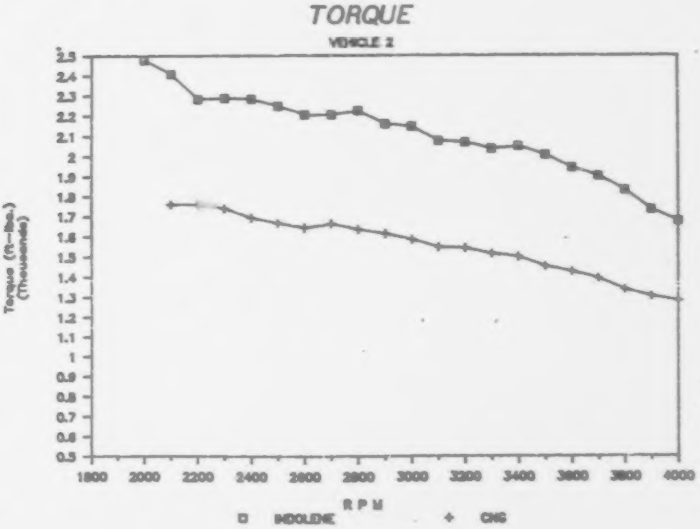

Figure C18: Torque - Indolene Without Kit vs CNG - Vehicle #2

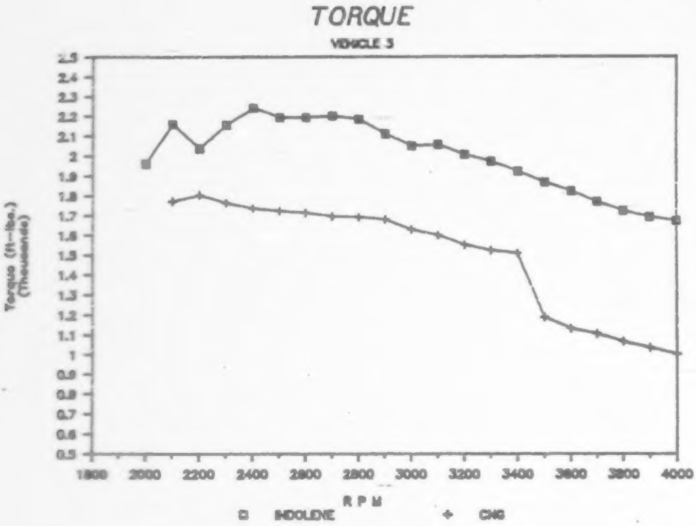

Figure C19: Torque - Indolene Without Kit vs CNG - Vehicle #3

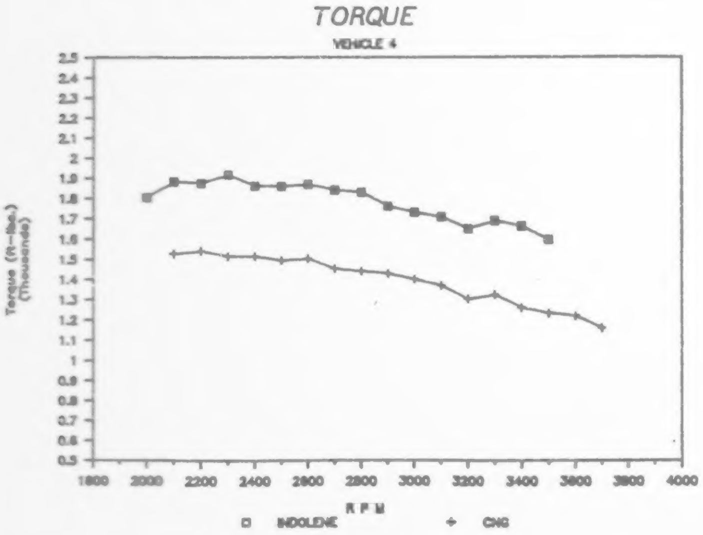

Figure C20: Torque - Indolene Without Kit vs CNG - Vehicle #4

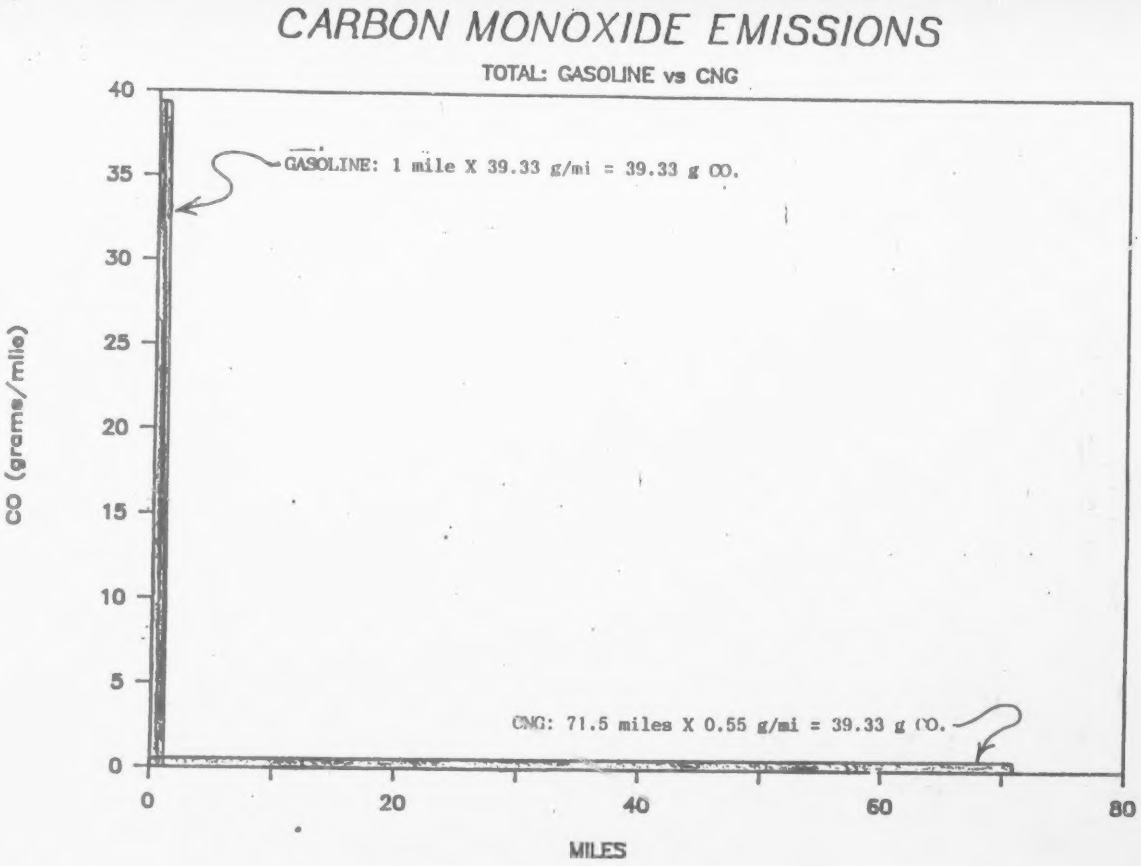

Figure C21: Equivalent CO Emissions (FTP & HFET Average) - Converted Vehicle - Gasoline vs CNG

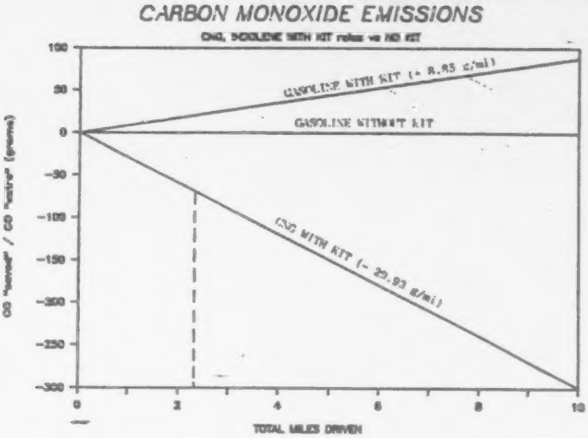

Figure C22: CO Emissions (FTP & HFET Average) - Gasoline Without Kit vs Gasoline With Kit & CNG With Kit

Senator ROCKEFELLER. Thank you very much, Mr. Yuhnke. I will have questions for you also.

Mr. Back from the Kanawha Valley Transportation System, we are very glad to have you, sir. And, of course, I am very proud to be one of your riders.

STATEMENT OF MILTON BACK, GENERAL MANAGER, KANAWHA VALLEY REGIONAL TRANSPORTATION AUTHORITY

Mr. BACK. Thank you, Mr. Chairman. I am the General Manager of the Kanawha Valley Regional Transportation Authority, the mass transit provider in Charleston, West Virginia, serving the entire area of Kanawha County. We are classified as a small transit system, and I am here today just to give you some insight into the potential impact and the pros and cons as we see them from the standpoint of a user of alternative fuels and in our case specifically methanol.

A little bit about our system. We run 63 buses in Charleston and we carry 2.5 million passengers annually. We receive funding from a number of sources. We have our operating revenues. We receive subsidies from the Federal Government, and the taxpayers of Kanawha County provide over 50 percent of the annual $5.75 million that it takes to run our transit system.

Our interest in alternative fuels is basically from two standpoints. Number one, as you well know, the economy in our part of the State of West Virginia is based primarily around the coal and chemical industries. We think and we understand, of course, that these two industries are primary players in the methanol field. Although coal is not currently one of the major factors in the production of methanol, it has the potential to be. And we feel a commitment as the public transit provider to get involved in the research that needs to be done in the actual use of methanol for the future economy of the State of West Virginia. The chemical industry as well has a major role to play in that.

The second reason that we are involved in the use of alternative fuels has been alluded to earlier in the EPA regs that have been issued some time back and take place for city transit buses in the year 1991. We have emissions standards that we must meet on buses purchased after 1991 that cannot currently be met by the production model diesel engines that are on the market today. The trucks of our Nation do not have to meet this standard until 1994.

The fact that fewer than 4 percent of the engines manufactured go into city buses leaves us with the situation that the engine manufacturing industry does not have a great incentive to produce an engine to meet the particulate standard that has been mandated strictly for the city transit buses. So, our option then is to go to alternative fuels.

The other option which has a very negative effect and I am afraid we will be seeing around the country is the fact that many mass transit systems will delay purchasing new vehicles until the trucks have to meet the standard in 1994 and thereby continuing to run the older vehicles which are more polluting than the ones currently available.

KRT must replace in the next three to 4 years, during the time period that this reg will take effect, 23 buses in our current fleet. And this is a very expensive proposition. The cost of a bus designed now specifically for burning methanol will run anywhere from $50,000 to $60,000 more than a bus designed to burn diesel fuel. So, cost becomes a very major factor.

The Alternative Motor Fuels Act of 1988 that you sponsored has done a lot toward encouraging the development of the alternative fuel technology and, as a matter of fact, Detroit Diesel, the major supplier of the heavy duty engines used in buses, does now have a production model methanol burning engine.

Most of the testing that has been done in transit buses to date has been done with engines that were modified diesel engines. There has been quite a bit of trouble with those engines and more research needs to be done. However, the newer engine that I believe Los Angeles has just taken delivery of a number of buses containing the methanol designed engine we believe will prove to be or hope will prove to be certainly more efficient and provide better performance than a modified diesel engine.

Some of the areas that smaller transit systems such as ourselves will face that I would like to just point out to you today—again, as I stated, the cost of the buses that will burn methanol is a big factor. One of the things that we are doing in West Virginia—and we are very encouraged by this—is we are going ahead with the assistance of the state. Governor Caperton's administration has been most helpful in providing funds for the purchase of some methanol vehicles. KRT is on the verge of placing an order for at least three of those vehicles, and we hope that further down the road there will be more of these to come.

Senator ROCKEFELLER. The funding for that from the state side is quite secure.

Mr. BACK. It appears to be, yes. We are very confident that it is going to be there. We received the assurance from the governor that the money will be there.

On the other side of that, the money that we will get from the State will be to match Federal funds. The Urban Mass Transportation Administration has certainly encouraged the purchase of the methanol-powered buses, and they will provide 75 percent of the cost. The 25 percent is what the state is committing to help us proceed with the program.

Other factors specifically in funding have to do with the operating cost of the methanol-powered vehicles. Right now in our area, the cost of methanol is substantially higher than the cost of diesel fuel. Our closest supplier will be in Cincinnati, the Ashland Chemical Company, and as a result, the transportation cost just to get the methanol to Charleston will be quite substantial. We will be paying approximately 20 cents a gallon more for methanol than we are currently paying for diesel fuel.

The other side of that, in California for instance, where a number of bus systems are using methanol already, they are paying 47 cents a gallon currently for their supplies of methanol which is substantially less than diesel.

I guess the point to be made here is that there are going to have to be some up-front sacrifices cost-wise, at least for us, to get involved in this program, but we very firmly believe in the program. We believe that we have a role to play and we believe that research from our operation in the terrain that we operate in, the climate that we operate in will be very beneficial in the future use of methanol around the country.

How to overcome some of the problems that we face? We believe that continued joint Government and private sector involvement in research and development of both the fuels and the engines is extremely important, and we certainly encourage the Government to continue building on the program that was developed last year in the Alternative Fuels Act.

Secondly, the availability of the fuel to us is very important. Some incentive needs to be provided for the suppliers of these alternative fuels to bring them into all areas of the country so that we can have access to them at an affordable cost.

Funding sources. Transit over the last number of years has received rather dramatic cutbacks in its funding at the Federal level. This resulted from efforts to cut the Federal deficit. I am not here to complain about that. Most agencies of government have taken substantial cuts in recent years and I believe probably will continue to do so for some time.

However, just speaking in my own words right now, the fact that a few years ago the number one priority of the citizens of this country I think was the reduction of the Federal deficit. And I believe today, as we have heard in the previous testimony, that if you took a survey of the public generally, the number one concern is going to be the environment and the clean air concerns that we have.

Senator ROCKEFELLER. I hope we do a better job on that than we have on the reduction of the Federal deficit.

Mr. BACK. I do too.

I believe that some dedicated source of funding is going to have to be developed for public agencies such as ourselves who have very limited resources to work with in order to get the transit systems and other public agencies into this alternative fuels market. The expense is going to be great. There needs to be some consideration for a specific or dedicated funding source to help those agencies who are willing to take on the research needed to develop the alternative fuels program.

Finally, one other area that we find that we need assistance in as a small transit system with a limited budget, we have very limited staff expertise. The technology that is involved in the alternative fuels, the research that needs to be done, the monitoring of the programs, the development of the programs in our area, is going to require some assistance both from the private sector and from the colleges and universities in the area. And we are already working with those to provide some staff time to assist us in monitoring our program and use of the methanol technology. And we believe that some consideration should be given to a program to encourage colleges and universities as well as the private sector to assist in the efforts of smaller public agencies such as ourselves and our involvement with alternative fuels.

I would like to say that on behalf of Kanawha Valley Regional Transit, we certainly appreciate the chance to discuss these concerns with you today, and it has been a pleasure doing so.

[The prepared statement of Mr. Back follows:]

Testimony

on

The Use of Alternative Motor Vehicle Fuels

Submitted to

The Senate Energy and Natural Resources Committee

Subcommittee on Energy Research and Development

United States Senate
June 6, 1989

By

The Kanawha Valley Regional Transportation Authority
P. O. Box 1188
Charleston, West Virginia
25324

Mr. Chairman and Members of the Committee my name is Milton Back, I am the General Manager of the Kanawha Valley Regional Transportation Authority (KVRTA), and I appreciate this opportunity to discuss with you the use and impact of alternative fuels on our operations. KVRTA is a public mass transit system serving Kanawha County and located in Charleston, West Virginia. We operate a fleet of 63 vehicles, including buses and vans in an urban area of less than 200,000 population with an annual ridership of 2,500,000 passengers. Funding for our operations is derived from operating revenues (29%), a local excess property tax (51%) and federal assistance (20%). Our annual expenses total $5.75 million.

KVRTA's interest in the use of alternative fuels is highlighted by two major factors;

1. The economy of our region is greatly influenced by the coal and chemical industries, primary participants in the development and manufacture of alcohol based fuels. As a public transit operation, we feel that our role in the use of alternative fuels is an appropriate one indeed since the economic base of our area is dependent upon the future of these industries. While areas such as California have the target markets for these types of fuels, West Virginia is the source for much of this nation's coal and chemical technology and supply.

   Geographically, KVRTA is located in an excellent area to test and determine the feasibility of alternative fueled vehicles. Kanawha County experiences a wide range of climates during the four seasons and with the extremes in terrain and road conditions will provide a testing ground for this type of vehicle unlike any other areas in which methanol-powered buses are operated.

   A positive experience by KVRTA will have a profound impact on the nation's alternative fuels initiative. The size of our system, the geography of our operating area as well as the economic impact to our state could prove that alternative fueled buses can work outside of major Metropolitan areas.

2. Recent EPA emission requirements mandating a much lower particulate standard of 0.1 G/BHP-H (Grams per brake horsepower hour) for transit buses beginning in 1991. This requirement cannot be met by current production model diesel engines and, since heavy-duty trucks are not required to meet the standard until 1994, the development of such a diesel engine could be several years away as less than 5% of all heavy-duty diesel engines produced go into transit buses. This situation leaves transit operators only two basic options;

a) Curtail the purchase of new buses until a diesel engine meeting the requirement is developed or;

b) Purchase buses with engines designed to run on alternative fuels such as methanol or natural gas.

KVRTA's current fleet of transit buses include twenty-three (23) that are due for replacement in the 1991-94 time period and our plans call for at least a portion of those to be powered by alternative fuels (methanol).

The use of alternative fuels by a transit system of our size raises a number of issues which need the immediate attention of your subcommittee and the federal government generally. The most obvious concern is the financial impact such a program will have on our operation:

- Capital Outlay - The cost of a transit vehicle designed to use methanol is estimated to be approximately $50,000 more than one powered by diesel fuel ($200,000-$225,000 range). In addition, facility renovations to store and dispense the fuel and to provide a safe working area to service and maintain the vehicles will add another $200,000-$300,000 cost to the project. Although the Urban Mass Transportation Administration (UMTA) provides funds for capital assistance, these programs require a local match of 20-25%, which is a substantial obligation on an operation whose financial resources are as limited as ours. We have been informed by UMTA officials that demonstration grants (100% funding) for methanol projects are no longer available.

- Operating Expenses - The use of methanol as an alternative fuel will greatly increase operating expenses in the short term. Our present quotes on the costs of methanol indicates that the average price will be $.25 per gallon higher than diesel fuel. This, combined with the fact that methanol, on a miles per gallon basis, will only go half as far as diesel, interprets into a substantial increase in operating costs. Hopefully, in time, increased production of methanol and more efficient engines will turn this situation around. The use and maintenance of methanol powered vehicles will also require extensive education and training of our maintenance personnel. Again, UMTA's operating assistance grants provide some funding to meet these ongoing costs, but this program has been severly impacted by efforts to reduce the federal deficit. KVRTA's current annual appropriation of $822,000 is nearly $1 million less than our appropriation of $1.8 million in 1982.

Another area of concern to an operation of our size is the availability of technical assistance needed to begin, maintain and monitor the program. To obtain the expertise needed on a staff level is impractical. We must be able to locate assistance from the private sector and/or from local colleges and universities.

To summarize, let me state that the efforts of the federal government and this subcommitee to improve air quality and to lesson dependence on petroleum imports through the use of alternative fuels is very commendable and we applaud your efforts. However, the government alone cannot assure the success of the nation's alternative fuel initiative, private sector involvement is a key component. Manufacturers of engines, fuel and vehicles must get involved and accelerate their efforts in this arera. If the private sector does not commit to this program then the fruition of the government's effort is years away. In our opinion, to make such a program a reality will require a sincere committment in the following areas:

- Availability and Affordability of Fuel - The use of legislative incentives to encourage the development, production and storage of fuels such as methanol is essential if consumers such as ourselves are to obtain the product at affordable prices.

- Engine Research and Production - The "Alternative Motor Fuels Act of 1988" encourages the production of alternative fueled vehicles. Due to the EPA standards, additional efforts should be made to accelerate the mass production of these engines.

- Funding - In view of recent cutbacks in federal funding for mass transit, new programs must be implemented to provide the financial resources necessary to offset the increased capital and operatings expenses. Perhaps a dedicated gasoline tax for this purpose should be considered and would be certainly be appropriate.

- Technical Assistance - Small transit systems with limited staff expertise in this highly technical area must be able to draw such resources from other areas. Specific grants to colleges and universities would be most helpful.

Thank you for your consideration of these remarks.

Senator ROCKEFELLER. Thank you, Milton, very much.

Now, Dr. Bowditch from the Motor Vehicle Association.

STATEMENT OF DR. FRED W. BOWDITCH, VICE PRESIDENT, TECHNICAL AFFAIRS DIVISION, MOTOR VEHICLE MANUFACTURERS ASSOCIATION OF THE UNITED STATES, INC.

Dr. BOWDITCH. Thank you, Mr. Chairman.

My oral statement will summarize my full statement which has been filed for your record.

I am Fred Bowditch, Vice President, Technical Affairs, of the Motor Vehicle Manufacturers Association, or MVMA. I am here today testifying on behalf of the MVMA member companies who manufacture 97 percent of the motor vehicles built in this country.

MVMA member companies have appeared before committees of the Senate and the House on several occasions to express their support for the development of an alternative fuels capability for the U.S. transportation sector. MVMA and its members supported passage of the Alternative Motor Fuels Act of 1988 and congratulate you, Senator, for your foresight in initiating that legislation.

Now it is time to take a look at where we are today and decide what actions are necessary to move forward.

Members of MVMA have made significant progress in the development and testing of alternative fueled vehicles over the past several years and are committed to continue with those efforts. In fact, several of our member companies have recently concluded or are about to conclude agreements with California authorities to provide in total a large number of methanol demonstration vehicles. And you talked a little bit about that program a little earlier in the testimony.

MVMA, however, believes that alternative fuel vehicle mandates are premature due to the substantial technical, environmental, engineering and economic issues that are still unresolved regarding their potential. Specifically studies are needed to assess the projected air quality benefits, to evaluate the global climate impact, the estimate the energy security implications, to measure the economic practicability and cost effectiveness of alternative fuels and to determine areas where further research may be necessary.

Therefore, MVMA recommends the initiation of a meaningful alternative fuels pilot program on cars, light trucks and buses and a simultaneous joint industry-government research effort to determine the potential of alternative fuels and to resolve the major scientific uncertainties regarding possible air quality benefits, health effects and the possible impact of such fuels on global warming.

Senator ROCKEFELLER. Dr. Bowditch, a vote is just starting. I could wait another three minutes, but let me just go down and vote and come right back. And then I have very specific questions for each of you gentlemen that I am very anxious to ask. So, please excuse me and we will stand in recess for hopefully no more than 6 or 7 minutes. I apologize to you, sir.

[Recess.]

Senator ROCKEFELLER. Dr. Bowditch, again I apologize to you. It was not an easy vote it turned out. So, there had to be some consultation.

Dr. **Bowditch.** I understand.

Senator **Rockefeller.** So, please proceed.

Dr. **Bowditch.** Well, thus far much has been learned about both the advantages and the disadvantages of each of the alternative fuels investigated, including the alcohols, gaseous fuels and electricity. These are detailed in the full statement filed with the subcommittee.

Methanol and ethanol are the primary alcohol fuels that have been investigated for their potential use in motor vehicles as far as we are concerned. They have a significant edge over other alternative fuels because they are liquid. But because ethanol is projected to cost more than methanol, manufacturers' research and development efforts have concentrated primarily on methanol.

Methanol's advantages are well-documented, but a number of technical issues regarding methanol-fueled vehicles remain open and need resolution. Methanol-fueled spark ignition engines are difficult to cold start even at moderate temperatures. Therefore, the 85–15 percent mixture of methanol and gasoline, or M85, has been proposed.

Long-term durability of engines, especially in cold climates, has not been confirmed. Lubricant specifications that address cold weather operation and the increased levels of acids from fuel combustion have not been established.

Perhaps most importantly customer acceptance of reduced range and increased frequency of refueling due to the lower energy content per gallon of methanol is a further concern, and there are other questions.

Methanol also has very low self-ignition properties, thus requiring the use of additional means to initiate and support combustion if it is used as a substitute for diesel fuel. Another disadvantage of methanol compared to gasoline and diesel fuel is the increased emission of formaldehyde that we have already discussed.

The concern over fuel availability while the supply infrastructure is established prompted the development of a light duty, flexible fuel or variable fuel vehicle, known as an FFV. An FFV has the ability to operate on gasoline, M85, or any random mixture of these fuels in a single fuel tank, as well as on other alcohols. However, for diesel engines, the methanol FFV concept cannot be used because methanol and diesel fuel are not miscible.

The pilot program we propose should include the following elements.

First, the broad-based participation and support by the Federal and local governments, vehicle and engine manufacturers, energy companies, and government and corporate fleet operators.

Secondly, it should focus on a two or three key nonattainment areas that represent different geographic and climatic conditions.

Third, commence no earlier than the 1992 time frame for the necessary commitments to be made by all participants.

Fourth, represent a test fleet of approximately 5,000 vehicles per test region. Each test fleet should accommodate vehicles capable of operating on any of the clean fuels so that each can be evaluated.

Fifth, it should provide for a minimum of two to three years' operating experience for the vehicle test fleet in each region to yield sufficient vehicle performance data to resolve the open-ended questions.

Sixth, it should include the evaluation of whether incentives are necessary or appropriate to stimulate participation in alternative fuel vehicle programs and assess the costs of incentive options.

Seventh, it should establish a mechanism for periodic review during the course of the pilot program of field experience being gained.

And finally, simultaneously a joint industry-government research program needs to be undertaken to resolve open scientific issues with regard to possible air quality benefits, health benefits and the impact of such fuels on global warming.

In conclusion, MVMA believes that a meaningful alternative fuel vehicle pilot program along the lines we have suggested is an essential step in the development of an alternative fuels capability for the U.S. transportation sector.

Thank you, Senator.

[The prepared statement of Dr. Bowditch follows:]

Statement of the

MOTOR VEHICLE MANUFACTURERS ASSOCIATION OF THE UNITED STATES, INC.

On

ALTERNATIVE FUEL VEHICLES

Hearing of the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

June 8, 1989

Washington, D.C.

Good afternoon, I am Fred W. Bowditch, Vice President, Technical Affairs of the Motor Vehicle Manufacturers Association of the United States, Inc. (MVMA). I am here today testifying on behalf of MVMA member companies who manufacture 97 percent of the motor vehicles built in this country.

Representatives of MVMA member companies have appeared before committees of the Senate and House on several occasions to express their support for the development of an alternative fuels capability for the U.S. transportation sector. MVMA and its members supported passage of the Alternative Motor Fuels Act of 1988 and congratulate Senator Rockefeller for his foresight in initiating that legislation.

Now it is time to take a look at where we are today and decide what actions are necessary to move forward.

Concerns about air quality, global climate change and energy security have intensified interest in a national program to force the further development and availability of motor vehicles capable of operating on alcohol or gaseous fuels and electric vehicles as an alternate to the use of gasoline and diesel fuel. Members of the Motor Vehicle Manufacturers Association (MVMA) have made significant progress in the development and testing of alternative fuel vehicles over the past several years, and are committed to continue those efforts.

In fact, several of our member companies have recently concluded, or are about to conclude, agreements with California authorities to provide, in total, a large number of methanol demonstration vehicles.

The Motor Vehicle Manufacturers Association, however, believes that alternative fuel vehicle mandates are premature due to the substantial technical, environmental, engineering and economic issues that are still unresolved regarding their potential. Specifically, studies are needed to:

- assess the projected air quality benefits;
- evaluate the global climate impact;
- estimate the energy security implications;
- measure the economic practicability and cost-effectiveness of alternative fuels; and
- determine areas where further research is necessary.

Therefore, MVMA recommends the initiation of a meaningful alternative fuels pilot program on cars, light trucks and buses, and simultaneous joint industry/government research efforts to determine the potential of alternative fuels and to resolve the major scientific uncertainties regarding possible air quality benefits, health effects and the possible impact of such fuels on global warming.

Thus far, much has been learned about both the advantages and disadvantages of each of the alternative fuels investigated, compared to petroleum. The efforts undertaken to date have also identified substantial technical, engineering and economic challenges -- including the important question of consumer acceptance -- that must be evaluated in a meaningful pilot program and resolved before the real potential of alternative fuel vehicles can be demonstrated.

Some key examples of what is known and what remains to be resolved regarding alternative fuel vehicles include the following:

Alcohol Fuels

Methanol and ethanol are the primary alcohol fuels that have been investigated for their potential use in motor vehicles. Most methanol today comes from natural gas, but it can be produced from coal and wood. Ethanol is largely made from grain or sugar cane.

Methanol and ethanol have a significant edge over other alternative fuels because they are liquid. This facilitates adaptation of vehicle fuel handling systems and the fuel supply infrastructure. Functionally, methanol and ethanol have many similarities. But, because ethanol is projected to cost more than methanol in most areas of the world, manufacturers' research and development efforts have concentrated primarily on methanol.

Methanol's advantages compared to gasoline include higher octane, flame speed, and latent heat of vaporization, all of which facilitate thermal efficiency and power improvement in spark ignition engines. Broad flammability limits provide potential for leaner operation. A key disadvantage of methanol fuel is increased emissions of formaldehyde. Although these emissions may be controlled with conventional technology, the degree of control at high mileage is unknown at this time.

A number of technical issues regarding methanol fuel vehicles remain open and need further effort for satisfactory resolution. Methanol-fueled spark ignition engines are difficult to cold start even at moderate temperatures, due to methanol's single boiling point and low vapor pressure. Long term durability of engines, especially in cold climates, has not been confirmed. Lubricant specifications that address cold weather operation and the increased levels of acids from fuel combustion have not been established. Customer acceptance of reduced range and increased frequency of refueling due to the lower energy content per gallon of methanol relative to gasoline or diesel fuel, is a further concern. And other significant questions remain about the economic practicability of alternative fuels.

Methanol's advantages relative to diesel fuel are: nearly smoke free combustion which provides for very low particulate emissions, and lower combustion temperatures which reduce the emission of nitrogen oxides. However, methanol has very low self-ignition properties, thus requiring the use of additional means to initiate and support combustion such as electrical systems, fuel additives or engine modifications. Another disadvantage of methanol, compared to diesel fuel, is the increased emission of formaldehyde.

Concerns about potential health effects of methanol and likely emission products have been raised and are being addressed by various government and industry groups. For example, questions about potential ingestion and flammability will need continued consideration.

The concern over fuel availability while the supply infrastructure is established, prompted the development of a light duty flexible fuel or variable fuel vehicle (FFV). An FFV has the ability to operate on gasoline, M85 (methanol blended with 15 percent gasoline), or any random mixture of these fuels in a single fuel tank, as well as on other alcohols. However, for heavy-duty diesel engines, the methanol FFV concept cannot be used because methanol and diesel fuel are not miscible.

Gaseous Fuels

Experience in this country with liquefied petroleum gas (LPG) and compressed natural gas (CNG) has been more limited than with alcohol alternative fuels. Both LPG and CNG have desirable combustion properties for use in spark ignition engines, including high octane. Also, the direct use of natural gas as an alternative fuel would eliminate the energy consumed in converting natural gas to methanol. Some of the technological challenges of gaseous fuels, however, include engine durability, potential safety concerns due to the pressure under which these fuels are stored in the vehicle, increased nitrogen oxide emissions and, for compressed natural gas, reduced energy density and, thus, driving range.

Electric Vehicles

Some MVMA companies have cooperative research programs with the Federal Government for electric vehicles. Preliminary estimates of potential electric vehicle costs -- batteries not included -- are comparable to gasoline and diesel fuel vehicles. Additionally, electric vehicles should enjoy energy costs that will be less than those of conventional fuels. However, the cost of the batteries is expected to cause the total cost of ownership to be above that of conventionally-fueled vehicles. Electric vehicle driving ranges appear to be limited to approximately 100 miles for the foreseeable future. This may only be acceptable for vehicles that never travel more than 100 miles in a day and where overnight recharging does not conflict with or affect usage needs. The present research vehicles achieve 0-50 miles per hour in less than 20 seconds, an acceleration that is slower than typical new cars. Emissions on a per-vehicle basis are very favorable for electric vehicles. However, any emissions from the generation plant will obviously impact the net benefit. Thus, electric vehicles are believed to have potential for a small niche market, but a major technological breakthrough is needed to provide costs, driving range and performance characteristics comparable to conventionally-fueled vehicles.

The Pilot Program

The pilot program should include the following elements in order to provide meaningful data on the open technical, environmental, engineering and economic issues:

- Broad-based participation and support by the Federal and local governments, vehicle and engine manufacturers, energy companies and fleet operators, particularly government and corporate fleets.
- Focus on two or three key non-attainment areas that represent different geographic and climatic conditions in the pilot program to test the performance and durability of alternative fuel vehicles under such conditions.
- Commence no earlier than the 1992 timeframe -- the earliest realistic time for the necessary commitments to be made by all participants to assure a meaningful and effective pilot program.
- Represent a test fleet of approximately 5,000 vehicles per region participating in the pilot program. Each test fleet should accommodate vehicles capable of operating on any of the clean fuels and not limited to vehicles dedicated to only one or two fuels. In this way, each of the potential fuels could be evaluated.
- Provide for a minimum of two to three years operating experience for the vehicle test fleet in each region. This would yield sufficient vehicle performance data to resolve, hopefully, certain of the key technical and engineering issues. In addition, such a minimum period of time is needed to provide answers to open fuel supply infrastructure questions, consumer acceptance of alternative fuel vehicles and potential economic impediments to broader-scale alternative fuel vehicle use.

- Include the evaluation of whether incentives are necessary or appropriate to stimulate participation in alternative fuel vehicle programs, and assess the costs of incentive options.
- Establish a mechanism for periodic review during the course of the pilot program of field experience being gained so that adjustments can be made to assure the overall effectiveness of the effort.
- Ensure that the pilot program is large enough to provide meaningful answers to the following issues:
  - Vehicle technical issues including cold start, durability, reliability, lubrication, materials compatibility, ability to control currently unregulated pollutants (including aldehydes), etc.
  - Appropriate fuel and additive formulation, including provisions for fuel handling.
  - Availability and cost of fuel.
  - Fuel infrastructure development.
  - Marketability and consumer acceptance of alternative fuel vehicles and alternative fuels.
  - Impact on energy usage, including energy production and fuel economy.
- Simultaneously, joint industry/government research programs need to be undertaken to resolve open scientific issues with regard to possible air quality benefits, health effects, and the impact of such fuels on global warming.

In conclusion, MVMA believes that a meaningful alternative fuel vehicle pilot program, along the lines we have suggested, is an essential step in the development of an alternative fuels capability for the U.S. transportation sector.

Senator **Rockefeller**. Thank you, sir. And on my fourth try, I will get your name right. Bowditch.

Dr. **Bowditch**. Yes, sir. Thank you.

Senator **Rockefeller**. Mr. Smith, if I may ask you some questions, sir.

Mr. **Smith**. Certainly.

Senator **Rockefeller**. I notice in one of your statements that Chevron strongly supports vehicle demonstration programs to learn more about the performance and the environmental impact of alternative fuels.

Mr. **Smith**. That's true.

Senator **Rockefeller**. That is correct, isn't it?

Mr. **Smith**. Yes.

Senator **Rockefeller**. I simply wanted to emphasize that for the record because I think it underscores the broad consensus even among those, although you said you were not necessarily a skeptic of methanol, who question methanol. There is nevertheless a broad consensus that demonstration projects need to be undertaken and that you should know that I have been fighting very hard for full funding of demonstration programs under the bill that we passed last year.

In your testimony and correspondence, in fact, with me, you have written some rather broad assertions suggesting that the potential of methanol in dealing with air quality problems is doubtful. As you know, EPA and the California Air Resources Board take a rather different view. The validity of the Sierra Research Study on which you rely and which I believe, if I am not incorrect, your company paid for—am I right?

Mr. **Smith**. We were one of the sponsors of the program along with other oil companies.

Senator **Rockefeller**. Of the study.

Mr. **Smith**. Of the study, yes.

Senator **Rockefeller**. Along with?

Mr. **Smith**. Other oil companies.

Senator **Rockefeller**. There has been a fairly serious impeachment, in my view, of some of the conclusions that have been drawn from that study by the California Air Resources Board. And if there is no objection, I am going to enter some of those impeachments.

I would like to pursue another point and one point that you make about formaldehyde problems with methanol. Critics of methanol often say that there are greater formaldehyde tailpipe emissions with methanol compared to gasoline. This has been discussed this afternoon. But is it not the case that formaldehyde from methanol has much lower reactivity in the atmosphere?

Mr. **Smith**. That is dependent upon the assumptions that you put into your model. Carnegie Mellon University had certain assumptions placed in their model that indicated that using M85 or M100 would not increase the ambient formaldehyde levels. But again, it is what you put in the model that ends up with those assumptions.

Getting back to the Sierra Research activities, of course, CARB has impeached the study, but also Sierra has impeached the impeachment of themselves too. So, we have available the rebuttal that Sierra Research has given to the CARB.

Senator **Rockefeller**. And I would welcome to have that in record.

Mr. **Smith**. We will.

Senator **Rockefeller**. When you send it to me, I'll put it in the record.

[The information referred to follows:]

Chevron

Chevron U.S.A. Inc.
575 Market Street, San Francisco, CA 94105-2856

D. B. Smith
General Manager
Strategic Planning and Business Evaluation

1989 JUN 16 PM 3:18

June 12, 1989

The Honorable John D. Rockefeller IV
United States Senate
Washington, D.C. 20510

Dear Senator Rockefeller:

I enjoyed the opportunity to discuss alternative motor vehicle fuels with you and the other participants at the hearing on June 8th. As you requested, I am sending along a copy of the California Air Resources Board's critique of Sierra Research's critique of the Carnegie-Mellon University methanol substitution air quality modeling study, as well as a copy of Sierra Research's response to the CARB critique.

I would be happy to discuss the issues addressed in these documents with you at your convenience.

Sincerely,

Dixon Smith

Attachments

STATE OF CALIFORNIA
GEORGE DEUKMEJIAN, Governor

AIR RESOURCES BOARD
1102 Q STREET
P.O. BOX 2815
SACRAMENTO, CA 95812

February 9, 1989

Alan Lloyd, Ph.D.
Chief Scientist
South Coast Air Quality
  Management District
9150 Flair Drive
El Monte, CA 91731

Dear Dr. Lloyd:

During the AB 234 Environmental/Health and Safety Workshop, Sierra Research, on behalf of various petroleum refiners, presented the findings of their study investigating the assumptions and inputs to the Carnegie Mellon evaluation of the air quality impact of methanol fuel use. The California Air Resources Board has prepared a response to this presentation, in order to assist the committee responsible for the workshop as well as the entire Advisory Board in evaluating the air quality impacts of methanol-fueled vehicles. As indicated in the enclosure, we believe Sierra's analysis was faulty and does not support the conclusions they reached.

If you have any questions or comments regarding this response, please contact David Coel, Manager, Engineering Studies Section, Mobile Source Division, at (818) 575-6977. I trust that the information contained in the response will be beneficial and will facilitate a factual discussion of the air quality implications of all alternative fuels.

Sincerely,

Tom Cackette

Tom Cackette
Deputy Executive Officer

Enclosure

California Air Resources Board (ARB) Response to the Sierra Research Report Entitled "Potential Emissions and Air Quality Effects of Alternative Fuels".

During the recent AB 234 Advisory Board Workshop regarding the health, safety, and environmental implications of alternative fuel implementation, Sierra Research presented their evaluation of the air quality benefits of alternative fuels. Sierra Research, a consulting company that prepares reports for both public and private organizations, was funded by petroleum refiners to perform the study. The purpose of this response is to identify and discuss conclusions which Sierra reached that the ARB believes are technically unsupportable or could be easily misinterpreted in view of the complex issues involved.

Sierra offers some useful input regarding instrumentation used to measure methanol vehicle emissions, and covers promising gasoline vehicle emission control technology that could be applied in the near term (most of which has been described previously in an ARB Technical Support Document analyzing more stringent motor vehicle hydrocarbon and carbon monoxide standards); however, the overall conclusion of Sierra's study appears to be simply that gasoline vehicles are cleaner than methanol vehicles. In our view, the evidence Sierra uses to support this conclusion is weak and potentially misleading. It appears that Sierra misinterpreted vehicle emission control data, did not utilize available methanol vehicle emission data and apparently did not reconcile their conclusions with basic engineering tenets.

Sierra's principal conclusions and ARB's responses are as follows:

1) Sierra Conclusion: At comparable levels of emission control technology, gasoline vehicles emit lower oxides of nitrogen (NOx) emissions than methanol vehicles.

   ARB Response: The evidence Sierra uses as a basis for their argument is a comparison of gasoline vehicle certification data and prototype methanol vehicle data. Sierra states that this comparison is reasonable since gasoline vehicle certification data is based on emissions at 50,000 miles, while the methanol vehicle emission data is based on "hand-built" methanol vehicles which have mileages well below 50,000 miles. As discussed below, Sierra's analysis does not provide a meaningful comparison of the NOx emissions of gasoline and methanol fueled cars.

   In order for a manufacturer to obtain permission to sell a particular vehicle model in California, emission data (or more specifically certification data) must be submitted to ARB that demonstrates the vehicle model will have the capability to comply with emission standards in customer use at 50,000 miles. Vehicles generally used to obtain certification data are hand-built, with a large amount of engineering effort utilized to ensure that the vehicle will have the lowest possible emissions. In addition, mileage is accumulated on a laboratory dynamometer or a test track which does not simulate all the stress of real world conditions on the vehicle's emission control system. As a result, emissions of certification vehicles are usually much lower than emissions of production vehicles in customer service.

The prototype methanol vehicles presently in use, on the other hand, are for the most part assembly-line produced 1983-1987 gasoline vehicles that have been converted in the engineering laboratory to operate on methanol. Manufacturers generally have performed little emission control optimization of these methanol vehicles because the manufacturers' primary objectives have been to examine component durability, cold starting characteristics, and driveability. For these reasons, a comparison of emissions from highly optimized 1988 gasoline certification vehicles and older prototype methanol development vehicles can not be used to support a conclusion that one type of vehicle will have higher in-use emissions than the other.

There are also engineering reasons why NOx emissions from methanol vehicles should be no higher than NOx emissions from gasoline vehicles, given equivalent levels of emission control system optimization. NOx emissions are created during engine combustion, and the amount of NOx created is primarily a function of the peak temperature during combustion (higher temperatures form more NOx). Methanol has a lower peak combustion temperature than gasoline, and therefore, it would be expected that these vehicles produce less NOx emissions compared to gasoline vehicles. In practice, however, the high octane of methanol allows the compression ratio to be raised resulting in improved fuel efficiency, and NOx emissions which equal the NOx emissions of gasoline vehicles.

Recent testing of a variable fuel Chevrolet Corsica, which is the latest vehicle model to enter California's methanol fleet demonstration program, provides additional evidence that Sierra is incorrect in their conclusion regarding NOx emissions. (Variable fuel or fuel flexible means that the vehicle can automatically operate on gasoline, methanol, or any combination of the two fuels.) A Chevrolet Corsica emission tested by General Motors while operating on an 85 percent methanol/15 percent gasoline mixture (M85) achieved NOx emissions of only 0.2 g/mi, which is typical of the lowest NOx emissions being achieved by current gasoline cars. Discussions with GM engineers confirmed that they believe equally low NOx emissions can be achieved for either gasoline or methanol operation once differences in oxygen sensor aging characteristics are accounted for in the vehicle computer software.

2) Sierra Conclusion: Methanol vehicles produce as much highly reactive nonmethane hydrocarbon and formaldehyde emissions as gasoline vehicles.

ARB Response: Data collected at the ARB's vehicle emission laboratory show Sierra's conclusion to be incorrect for both M85 and M100 vehicles.

Methanol's potential as an air pollution control strategy for light-duty vehicles is based on the significantly lower reactivity (or ozone production potential) of its organic exhaust components compared to gasoline. With regard to methanol vehicles operated on M85, the organic portion of the exhaust consists primarily of low reactivity methanol, with small amounts of high reactivity nonmethane hydrocarbons and formaldehyde. The organic component of gasoline vehicle exhaust is mostly high reactivity nonmethane hydrocarbons. ARB has exhaust emission data from several fuel flexible Ford Crown Victorias and a Chevrolet Corsica operating on both M85 and gasoline that directly conflicts with Sierra's conclusion. Some of the data are shown in the following table.

Vehicle	Mileage	Nonmethane Hydrocarbons plus Formaldehyde (M85)	Nonmethane Hydrocarbons (Gasoline)
Corsica (Lic. 497AHU)	4,500 mi	0.13 g/mi	0.20 g/mi
Crown Victoria (Lic. E427963)	15,000 mi	0.14 g/mi	0.35 g/mi
Crown Victoria (Lic. E420928)	6,700 mi	0.05 g/mi	0.19 g/mi
Crown Victoria (Lic. E420927)	8,000 mi	0.07 g/mi	0.36 g/mi

ARB submitted these data upon request to Sierra Research well before the AB 234 workshop on the health, safety, and environmental implications of methanol compared to other alternative fuels. Apparently Sierra chose to rely only on data from Ford showing nonmethane hydrocarbon emissions plus formaldehyde from an M85 vehicle being in the range of 0.25 g/mi.

With regard to organic emissions from vehicles operating on M100, ARB recently tested a fuel flexible Crown Victoria with this fuel to verify engineering judgment, which reasons that nearly all of the organic emissions from this vehicle would consist of methanol since there is no gasoline component in the fuel. The exhaust emission results were as follows: 0.5 g/mi methanol (91%), 0.017 g/mi nonmethane hydrocarbons (3%), and 0.035 g/mi formaldehyde (6%). These data are in direct conflict with the Ford test results used by Sierra. Ford testified at the February 2 workshop of the Advisory Board on Clean Air and Fuels that it is premature to attach much significance to the data Sierra relied upon without undertaking additional verification and analysis. In addition, neither EPA nor ARB have measured significant HC levels in M100 tests, and except for a small amount due to oil consumption, none should be present.

3) Sierra Conclusion: Formaldehyde emissions from methanol vehicles will never be reduced to a comparable gasoline vehicle level.

ARB Response: ARB disagrees with Sierra, as they again focus on older technology vehicles and dismiss the low formaldehyde levels of the Toyota Carina which has been optimized for low formaldehyde emissions.

Based on input from industry sources (catalyst suppliers with extensive experience in catalyst technology), formaldehyde is a relatively easy component to oxidize into carbon dioxide and water, and there should be no significant impediment to reducing formaldehyde emission levels from current prototype methanol vehicles. Formaldehyde emission levels from these vehicles, which do not have optimized emission control systems, are approximately 20-30 mg/mi. Corresponding formaldehyde levels from gasoline vehicles ranges from about 5 mg/mi to 15 mg/mi. ARB has one methanol vehicle, a Toyota Carina (this vehicle is not sold domestically), that has an emission control system which reflects a first effort at optimized formaldehyde control. The Carina's formaldehyde emissions range from 9 mg/mi to 19 mg/mi.

Sierra argues that because engine-out formaldehyde emissions are higher on methanol vehicles, close to 100 percent catalyst efficiency would be required to achieve comparable levels to gasoline vehicles. Sierra cites one data point from Ford, derived from a fuel flexible Crown Victoria operating on M100, which produced an engine out formaldehyde rate of approximately 650 mg/mi. Again, engineering judgment should have directed Sierra to double check this information with publicly available data from ARB (Alcohol Fueled Fleet Test Program, Fourth and Eighth Interim Reports), especially since the Crown Victoria is optimized to operate on M85, not on M100 which causes cold start problems with attendant high emissions. ARB's emission data show an engine out formaldehyde rate of approximately 100 mg/mi to 200 mg/mi when using M85; catalyst efficiencies in the range of 90 to 95 percent would be required to achieve a comparable gasoline vehicle formaldehyde emission rate. Catalyst efficiencies in excess of 90 percent are feasible.

On page 18 of their report, Sierra cites as evidence that methanol vehicles cannot achieve gasoline vehicle formaldehyde levels the high engine-out formaldehyde emissions (300-600 mg/mi.) for the Toyota Carina (this is a lean-burn vehicle which operates on the ragged edge of misfire to achieve good efficiency - and this can result in higher formaldehyde levels from the engine). However, this vehicle, which features a catalyst optimized for formaldehyde control, has achieved formaldehyde emissions in the same range as gasoline vehicles despite its higher engine-out emissions. This represents a catalyst efficiency of greater than 90 percent. These data alone are enough to invalidate Sierra's conclusion.

4) Sierra Conclusion The Carnegie Mellon University (CMU) air quality modeling study is unrealistic since a number of poor assumptions were utilized. In particular, the emission rates used for methanol vehicles were extremely low and did not represent reality.

ARB Response: Optimistic emission rates were used for both advanced gasoline and advanced methanol fueled vehicles. This decision was based on several considerations. First, ARB's motor vehicle emission control plan sets forth a number of new control measures for gasoline and diesel fueled vehicles which will be considered for adoption over the next few years. If fully implemented, these control programs will result in emission rates for petroleum fueled vehicles which approach or equal those used in the CMU study.

This approach also addressed concerns raised by Sierra and others that methanol was being inappropriately considered a substitute for available controls on gasoline and diesel vehicles. ARB has always considered the use of alternative fuels as a complement to additional controls on conventional fueled vehicles. In particular, if preparation for the introduction of alternative fuels begins now, sufficient clean fuel vehicles could be in the fleet by the time the benefits of additional controls on petroleum fueled vehicles have been fully realized. Thus alternative fueled vehicles could provide the continuing improvements in air quality that will be needed beyond the turn of the century to attain ambient standards. It should also be noted that by assuming gasoline and diesel emission rates are very low, the benefit of substitution of methanol is also reduced, so that the estimates of air quality improvements derived from the CMU study can be considered a minimum. If in fact gasoline (and methanol) emissions prove to be higher than estimated, the benefit of methanol substitution will also be greater.

The second reason for the choice of optimistic emission rates relates to how the modeling results will be used. The evaluation of each scenario is very expensive, involving large amounts of computer time. A matrix of scenarios which covered the full range of expected outcomes was devised. For example, we evaluated both high and low emission rates. We also evaluated partial and full replacement of petroleum fueled vehicles with methanol fueled vehicles. By using this approach, it is possible to interpolate within the range of assumptions and scenarios evaluated. This allows many other scenarios to be evaluated without the need to perform additional, costly computer analyses.

Sierra also makes some misleading or erroneous statements in chapter 4 of their report concerning the CMU Study. On page 28, Sierra indicates that eliminating emissions from petroleum refining for the methanol scenarios is a poor assumption. ARB felt that this assumption should be evaluated since some scenarios involved the complete penetration of M100 vehicles into the fleet. In any case, it should be noted that refining emissions only account for about 4% and 2% of the ROG and NOx emission inventories, respectively, and therefore noninclusion of petroleum refining emissions has only a minor impact on ozone levels.

Sierra also incorrectly assumes on page 31 (CMU Scenarios 5 and 7) that NOx emissions of methanol heavy-duty engines are half those of gasoline or diesel heavy-duty engines. NOx emissions were assumed to be reduced by one half only for diesel vehicles, not gasoline engines. In this same scenario discussion, the text misleads the reader into believing that NOx emissions from methanol light-duty vehicles were half those of comparable advanced gasoline vehicles. The correct statement should be that NOx emissions from both advanced gasoline and methanol vehicles were the same (0.2 g/mi), which is half of the current standard for gasoline vehicles (0.4 g/mi). Also, on page 32 (Scenarios 6 and 12) Sierra incorrectly implies that a 3 mg/mi formaldehyde rate was used in these scenarios "as under scenario 5". Actually a 15 mg/mi formaldehyde emission rate from methanol vehicles was assumed for these scenarios and a higher 0.4 g/mi NOx emission rate until 1997. Sierra's comments under Scenario 10 are incorrect for the same reason.

5) Sierra Conclusion: Instrumentation used to measure methanol vehicle emissions does not have sufficient accuracy to enable proper characterization of methanol vehicle emission rates.

   ARB Response: ARB acknowledges that there is some room for improvement with regard to current instrumentation used to measure methanol vehicle emissions. However, it should be noted that ARB uses the best commercially available instrumentation (e.g., gas chromatographs and other advanced instruments), and ARB believes that this instrumentation is sufficiently accurate to characterize methanol vehicle emissions. As part of our effort to ensure that ARB's instrumentation is accurate, back-to-back emission tests have been performed on a number of vehicles between ARB's emission laboratory and Chevron's emission test facility in Richmond, California. To date, good agreement has been obtained. In addition, other less rigorous comparisons have been made among emission data gathered from ARB, Ford, and GM, and one can conclude that there is general agreement among these emission test facilities. It is ARB's conclusion that the accuracy of emission test results from methanol vehicles is sufficient to allow a comparison to emissions of gasoline and diesel vehicles, as was done in the CMU study.

6) Sierra Conclusion: Advances in emission control technology for methanol vehicles can be equally applied on gasoline vehicles to obtain equivalent emission levels for both types of vehicles.

   ARB Response: We agree that in general this is true. However, the organic emissions from a methanol vehicle will always be less reactive, and thus the exhaust of methanol vehicles will cause less smog formation than gasoline exhaust.

In summary, ARB disagrees with Sierra's basic conclusion that gasoline vehicles will be cleaner than methanol vehicles. Sierra principally bases this conclusion on an inappropriate comparison of gasoline vehicle certification data derived under laboratory conditions and emission results of non-optimized prototype methanol vehicles. The gasoline certification vehicles have received substantial emission control system optimization whereas methanol vehicle prototypes have had little or no emission control system optimization. It is our technical judgement that methanol vehicles will emit no more than gasoline vehicles using comparable emission control technology, and due to the lower reactivity of methanol exhaust, will contribute to lower ambient levels of smog. The CMU air quality study verifies this conclusion.

sierra
research

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February 15, 1989

Dr. Alan Lloyd
Chief Scientist
South Coast Air Quality Management District
9150 Flair Drive
El Monte, CA 91731

Dear Alan:

In an attachment to his letter of February 9, 1989, Tom Cackette provided you with ARB comments on the report we presented during the AB 234 Environmental, Health and Safety workshop that you chaired. ARB has attempted to dispute six of our conclusions regarding how the air quality benefits of methanol were exaggerated by the assumptions used in the Carnegie Mellon air quality modeling study. ARB obviously hopes to create the impression that, as Mr. Cackette's letter says, our analysis was "faulty". Unfortunately, some of the points ARB attempts to make in response to our presentation are supported only by inaccurate statements and unrepresentative data.

In our presentation, we attempted to deal with the common misperception that methanol-fueled vehicles are inherently cleaner than vehicles using gasoline. When ARB's methanol vehicle test results are compared to the official certification test results for gasoline vehicles, it is clear that gasoline vehicles compare quite favorably. ARB has responded to this element of our presentation by claiming "Vehicles generally used to obtain certification data are hand-built, with a large amount of engineering effort utilized to ensure that the vehicle will have the lowest possible emissions." We can only assume that this comment was prepared by a member of the ARB staff who is unfamiliar with the certification program. Build practices required for certification vehicles do not allow the type of fine-tuning alluded to. Manufacturers may not optimize certification vehicles. They must represent a mass-produced vehicle, not a hand-tailored prototype; in fact, EPA certification staff has confirmed to us that many vehicle manufacturers select their certification data vehicles from off the assembly-lines, in order to minimize their costs and ensure that they comply with EPA's requirements regarding representative construction. ARB's statement is a more accurate description of how methanol prototypes are constructed. The implication in ARB's comment that the test results we used for gasoline vehicles are unrepresentative of mass-produced vehicles is just plain wrong.

Clearly, both certification gasoline vehicles and methanol prototypes receive an above-average quality of treatment during mileage accumulation. But, the gasoline-fueled certification vehicles are not allowed to receive the extraordinary maintenance that many of the methanol prototypes have received. Thus, it is the methanol vehicle emissions that are relatively lower than would be expected in customer service.

Regarding our conclusions about the significant level of reactive organic emissions from methanol vehicles, ARB presents data for four "fuel flexible vehicles" using M85 with hydrocarbon plus formaldehyde levels ranging from 20-65% of the HC emissions from the same vehicle running on gasoline. Given the minimal mileage accumulated on these vehicles (only one above 10,000 miles), the data would appear to support our position that reactive organic emissions from methanol-fueled vehicles are substantial. With only 15,000 accumulated miles, one of the test vehicles is emitting 0.14 g/mi. This doesn't appear to be anything to brag about. Comparable performance has been demonstrated for gasoline vehicles. We disagree with the implication of ARB's remarks that the performance of FFVs on gasoline should be considered representative of the best available gasoline technology.

ARB's comment that "...neither EPA nor ARB have measured significant HC levels in M100 tests..." is a grossly misleading statement. Until recently, EPA and ARB haven't been measuring HC from M100 vehicles. It is difficult for us to comment on the M100 HC data presented in ARB's comments. When we asked ARB for data shortly before our presentation, we were told they had none. It would be interesting to know how much mileage had been accumulated on the catalyst on the FFV Ford that ARB now says had such low HC and formaldehyde emissions. Based on all of the data we have previously reviewed, it looks like it was a low mileage (green) catalyst, and therefore unrepresentative of the average emissions performance that can be expected in customer service.

Regarding formaldehyde emissions, ARB says they disagree with our conclusion that formaldehyde from methanol vehicles will never be as low as from gasoline vehicles using comparable emissions control systems. ARB cites data from a Toyota prototype as somehow disputing our position. The only vehicles we are aware of that have formaldehyde emissions comparable to gasoline generally have higher NOx emissions and low-mileage catalysts. For now, ARB speculation that further catalyst development will solve the formaldehyde problem is just that - speculation. The correct way to assess our conclusion would be to measure the formaldehyde emissions from a gasoline Toyota Carina which is equipped with the same high efficiency catalyst technology used on the methanol Carina cited by ARB, with both vehicles having sufficient mileage to ensure stabilized catalyst performance.

Regarding the emission factor assumptions used in the CMU study, ARB makes the statement that "...air quality improvements derived from the CMU study can be considered a minimum." This ignores the basic complaint Sierra had with the assumptions; i.e., the emission factors assumed for future gasoline vehicles *have already been achieved* in 50,000 mile tests and the emission levels assumed for methanol *have not*. We are disturbed to see ARB say that we made "misleading or erroneous" statements about the modeling assumptions while ARB claims that the benefits that the CMU study shows for methanol are the *minimum*. The assumed refinery shutdowns that we criticized were clearly an attempt to maximize the projected benefits of methanol. In response to our criticism in that area, ARB has chosen to make derogatory comments about our work and to make an incredible statement about the methanol benefits from the CMU study being the minimum possible. In our opinion, the "minimum benefits" of methanol will be an *increase* in ozone levels caused by the use of M85 vehicles that experience durability problems and/or fuel switching in customer service.

We agree with ARB's comment that organic emissions from methanol will always be less reactive, but that isn't the point. An equally important factor is that when comparable catalyst technology is applied to both gasoline and methanol vehicles, total organic emissions from methanol vehicles are *consistently higher*. This offsets the reactivity benefit.

Notwithstanding the above comments, we continue to believe that alternative fuels, including methanol, can contribute to improved air quality in California. Our main concern is with the tendency to see only the potential advantages of an alternative, and none of the potential pitfalls. We believe the concerns we have raised are legitimate and we believe a commitment to a methanol transition, especially involving M85 vehicles, is premature. As always, we remain willing to discuss this issue with you in greater detail.

Sincerely,

Tom Austin

Thomas C. Austin

Senator ROCKEFELLER. There is so little talk about benzene in gasoline. The gentleman who sits next to you just gave his testimony. In that he said gasoline is also virtually the only source of benzene in the human environment. The production, transport fueling and combustion of gasoline accounts for 99 percent of benzene exposure. The California report attributes 83 percent of benzene emissions to auto tailpipes. The California Air Resources Board estimates this causes between 100 to 1,000 leukemia deaths in the south coast air basin annually. I believe that is only four counties. On a national basis, benzene exposure could account for half or more of the 17,000 leukemia deaths each year.

Mr. SMITH. I am very interested in those statistics. I have not heard them before, nor do I know the source of the data.

One thing I did mention in the break was that our indications would show that humans' intake of benzene is much higher from the food we eat than the air we breathe.

Senator ROCKEFELLER. All right.

You have suggested that because of a lot of cheap natural gas in the Middle East, use of methanol is unlikely to reduce dependence on insecure sources of imported energy. This suggestion is at odds with a 1988 DOE report which notes that the sources of natural gas are more decentralized in fact than oil. The report also notes that even just increasing supplies in the Middle East would help by loosening up world energy prices. Is it not elementary economics that greater diversity and supply will undercut cartel tendencies?

Mr. SMITH. I would say yes, but still we have a problem if we are relying on another source of foreign imports. I would suggest that if you are really concerned about energy security and you switch to methanol, you are going to have to consider setting up a strategic methanol reserve to protect you from disruptions of methanol.

Senator ROCKEFELLER. Does it bother you that a third of our trade deficit is paying for imported oil?

Mr. SMITH. We would also be importing methanol, sir.

Senator ROCKEFELLER. Correct.

What is your view of the approach that—well, not correct. Short term correct, long term incorrect.

Mr. SMITH. I agree that long term we certainly have the potential to make much methanol from coal.

Senator ROCKEFELLER. And you would agree, for example, that Alaskan flared would be one of the very first and most obvious sources of natural gas for the use for methanol. Right?

Mr. SMITH. As part of the California methanol plant cost study, we did investigate the cost of making methanol from North Slope gas. Incidentally, that is gas being reinjected at the time, not flared.

Senator ROCKEFELLER. Right.

Mr. SMITH. And that is very expensive gas.

Senator ROCKEFELLER. But it is highly available.

Mr. SMITH. There is a lot of gas there.

Senator ROCKEFELLER. And if you were to bring things from Indonesia and other places, Algeria, et cetera, that would have a transportation cost associated with it, would it not?

Mr. SMITH. Yes, but our economics would indicate that methanol made from Alaskan North Slope gas would be much more expensive than methanol made from other remote locations such as Indonesia, Saudi Arabia, Jamaica.

Senator ROCKEFELLER. So, I will come back to my question about the fact that a third of our trade deficit is now importing of oil and that that is likely to be half of our trade deficit before very long. And, in fact, I think did not OPEC this morning or yesterday reached certain agreements?

Mr. SMITH. To increase production, yes.

Senator ROCKEFELLER. Yes. But you do not discount that as a factor in our trade deficit.

Mr. SMITH. No, not at all.

Senator ROCKEFELLER. What is your view of the approach that California is taking to dealing with smog?

Mr. SMITH. I think the South Coast Air Quality Management District is taking the right approach. They recognize that we do have to reduce automobile vehicle emissions. Also, in their plan, for example, in tier one of the plan, there are 120 other items that they are working on to reduce pollution. It is going to have an impact on everyone. Of course, the major pollutant there is from the vehicle, and their approach toward low emitting vehicle technology I believe is the correct approach.

As I testified, they did not specify any one particular alternative fuel. They are leaving it open at this point in time for private enterprise to come up with the best combination of a fuel engine emission control technology to help solve their problem.

Senator ROCKEFELLER. But if through the California experience, if California decides for itself and if the United States decides for itself for whatever reason that alternative fuels have to be an important part of our clean air approach, what approach would you suggest that we take in terms of alternative fuels?

Mr. SMITH. Certainly not a mandated approach. I would suggest a market incentive approach.

Senator ROCKEFELLER. And what if there cannot be reached an agreement on the market incentive approach?

Mr. SMITH. I think that reasonable people with consensus can reach agreement. We should strive for that.

Senator ROCKEFELLER. And I hope you are right.

You are pessimistic regarding the economics of methanol. I assume that you are aware that some projections are much more optimistic suggesting that in 20 years a methanol infrastructure and cars can be in place with prices at the fuel pump close to premium gasoline.

Mr. SMITH. I'm aware of that. I sit on the same advisory board with Chuck Imbrecht. We quite often on that board debate our views on future economics of methanol. He certainly has one view that differs from me.

I think it is a question of timing. We view methanol becoming economic when petroleum reaches $45 to $60 a barrel. He believes it will be economic at much lower petroleum prices.

Senator ROCKEFELLER. What kind of incentives would you suggest?

Mr. SMITH. If it is found that the use of methanol or any other alternative fuel is cost effective, as I suggested, then we should look at incentives. One incentive we might consider is the use of tax incentives where you increase the price of gasoline, increase the gasoline tax and give a credit on the alternative fuel.

Senator ROCKEFELLER. I had the feeling that up until several months ago the whole discussion about methanol—yes, there was a bill that had been passed, and I was very pleased about that—was kind of an esoteric, academic subject, not in California, not in Denver during the winter, but that now there are very strong hints that it is becoming much more than an academic subject and that health attainment standards under the Clean Air Act and a whole lot of other things, including global warming, are coming together in this country and causing people to rethink a variety of approaches. And the oil companies, at least Chevron—and maybe I falsely assume other oil companies—appear to me to be resisting methanol.

Mr. SMITH. Not at all. We believe that we should be part of the solution, not the problem. And if methanol is the solution for reducing pollution, is the solution for increased energy security, we are going to be providing methanol.

Our problem is not one of a chicken and egg problem. We talk quite often we have to break the chicken and egg problem. To me it is strictly a problem of economics. When will methanol be economic.

Senator ROCKEFELLER. To whom?

Mr. SMITH. To the public, to the manufacturer of methanol, to the manufacturer of the methanol compatible vehicle.

And so, I think what your role, what Government's role, should be is one of helping form a consensus on just when economics will occur that will allow this to move forward.

Senator ROCKEFELLER. You just think it is simplistic if I would just say that the oil companies, in that this is not oil that we are talking about, oil turning into gasoline—that is just old-fashioned thinking?

Mr. SMITH. Not at all. As I mentioned, we have the natural gas reserves. Chevron has the coal reserves. We are prepared to provide what fuel makes sense in the future. And if methanol is going to be economic, we will be there providing it tomorrow.

Senator ROCKEFELLER. Well, why wouldn't you be out in front? In other words, if you are in California and your people have the same problems with air and your retirees have the same problems with emphysema and other things, why would you choose not to be out in front? Why is that we have to be having this kind of a discussion?

Mr. SMITH. We see more cost effective ways of proceeding to reduce the pollution problem. We think that with modifications to existing gasoline, to existing diesel, we can come up with a more cost effective solution to pollution.

Senator ROCKEFELLER. Well, cost effective is one part of it. What about the cleanness of the product?

Mr. SMITH. That is part of it. What we have to do is to set the required tailpipe standards and other standards to reach the air quality goals, then let private enterprise determine the most cost effective way of getting there. We shouldn't go out and build 90 world-scale methanol plants to provide California with methanol, each plant costing in the neighborhood of $300 million to $400 million, when there are better ways to do it. Society does have enough money to spend it all on this. If there are better ways to do it, we should be doing it.

Senator Rockefeller. Chuck suggested that another approach would be simply to make a requirement that however it is that gasoline was produced, that it had to meet a level that would be achieved by methanol, and that it would be up to the oil companies as to how they wish to achieve that. How would you react to that suggestion?

Mr. Smith. Well, the first thing we have to remember is no fuel burns inherently clean. It is part of a system. It is part of the fuel, engine, control technology system. And as Mr. Bowditch will say, we have to tailor that system to the particular fuel. Just because you say you have methanol out here doesn't really say what is the impact on the environment. So, we have to look at the methanol. We have to look at the gasoline system. And you can't just look at the fuel and say one fuel has to be as good as the other because you are comparing apples and oranges there. You have to compare what the impact is on the environment. And that gets more difficult.

Senator Rockefeller. So, what was the answer to my question?

Mr. Smith. Well, I think I did.

Senator Rockefeller. Well, then try me again because it didn't appear to me to be that way.

Mr. Smith. What I am really saying is that——

Senator Rockefeller. Chuck made a specific suggestion.

Mr. Smith. Right, that you should set gasoline standards as tight as methanol. And what I am saying is that is comparing apples and oranges because you have to compare what the impact is on the environment coming out the tailpipe, and that is a function not of just the fuel, but also of the engine and the control technology on the vehicle. So, you have to compare the two systems, not just the fuel.

What you should do again is to set the emission standard necessary to meet the air quality goal and then everything is on the level playing field, and let free enterprise what is the best way to get there and the market will drive you there.

Senator Rockefeller. There are all kinds of air problems around. The oil companies own most of energy and sources of production. I guess I am just philosophically wondering why it is that this isn't somehow extremely exciting to you——

Mr. Smith. It is.

Senator Rockefeller. You realize that you have the economic wherewithal to take this and really run with it if you want to. It doesn't make any difference to me who produces methanol or alternative fuels. I just want to see action on this front. And, you know, Celanese does this. Somebody else does that. Eastman Kodak produces a little bit out of coal, for what purposes I know not, but they do it. I do not think it is probably very clean, but they do it. Why aren't you here kind of saying, look, we have the money, we have the expertise, we are going to make this thing work because we recognize that we have an environmental problem and, to boot, the consumer gets 111 octane and all the rest of it?

Mr. SMITH. We are not convinced that this is the way that it is going to be resolved in the future, that methanol is the panacea at this point.

Senator ROCKEFELLER. Well, you said fancy. You see that goes back to what I said at the beginning. I think it is something more than a passing fancy at this point.

Mr. SMITH. No, no. Excuse me. I didn't mean to say fancy. We are not convinced at this point that methanol is the panacea.

Senator ROCKEFELLER. Oh, panacea. I'm sorry.

Mr. SMITH. We firmly support more demonstrations. We need more work. And I would hope that Mr. Bowditch would agree on that.

Senator ROCKEFELLER. Let me try and put this in a different way too. We talk about the cost of moving to alternative fuels, cost effectiveness. This will be my last question.

Mr. SMITH. Plenty of time.

Senator ROCKEFELLER. Shouldn't we also, in fact, look at the current cost of air pollution?

Mr. SMITH. Yes.

Senator ROCKEFELLER. You are aware, I would think, that the estimate that, just for the four counties that I indicated of the South Coast Management District in California, the damage caused by air pollution to health and agriculture amounts to $9.6 billion annually. Put another way, are you aware that by this estimate an improvement of just 10 percent in ozone alone might save $240 million a year in those counties?

Mr. SMITH. I'm not aware of those estimates.

Senator ROCKEFELLER. That is part of cost effectiveness for something, isn't it?

Mr. SMITH. Yes, but it could be much more effective to modify gasoline to reach the same levels of ozone than to switch to an alternative fuel.

Senator ROCKEFELLER. Do you support standards applying to both oil and cars?

Mr. SMITH. Certainly.

Senator ROCKEFELLER. Thank you, Mr. Smith, very much.

Mr. SMITH. You are welcome, sir.

Senator ROCKEFELLER. Mr. Bowditch, if I may ask you some questions.

With the Rockefeller-Sharp bill, Congress addressed one aspect of the need for incentives to promote alternative fuels. Just one. What other impediments are there in your judgment to the widespread use of alternative fuels, and what other steps can and should Congress take?

Dr. BOWDITCH. Well, Senator, I tried to outline in my testimony what step we think needs to be taken next. As you point out, we have indeed been working on methanol vehicles for the last several years.

Senator ROCKEFELLER. Let me interrupt my question because I think your answer is correct. You did answer it. You spoke to a lot of that.

What is the view of the auto industry of what it is that California is doing in dealing with smog, to the approach that they are taking?

Dr. **Bowditch**. Well, in particular the four southern counties and the organization that they represent really had little other alternative other than the type of plan that they eventually came up with. There really isn't much of anyplace else to go.

Senator **Rockefeller**. Would you agree that if those of us—and I assume that includes you who are interested in a market approach, incentives approach, to all of this, that if there can be no agreement on that, that Congress may be forced to go to mandates?

Dr. **Bowditch**. I can imagine that that may be the case. That is not the preferred case in our view, but I can imagine that that may be what has to happen.

Senator **Rockefeller**. And, therefore, you would feel that a solution to this is of such an imperative nature that something has to be done preferably incentives or market approach, but that failing that, there would have to be something nevertheless done.

Dr. **Bowditch**. There may be.

Senator **Rockefeller**. By the year 2000, California expects about 1 million alternative fuel vehicles on the road, mostly obviously in California. And that would meet a goal of 40 percent displacement of gasoline. Will the auto industry have any difficulty meeting that goal?

Dr. **Bowditch**. I think if we were to, indeed, be certain that that many vehicles would be saleable in the California area, that there would be enough customers that are willing to buy those types of vehicles, if we are assured that, indeed, that is the case in the relatively near future, I think our industry could produce that many cars.

Senator **Rockefeller**. I am curious. And I have said this often, and I just ask for your reaction.

The Japanese are clearly working on this.

And I remember when I went out to Detroit recently and I met with the three automobile companies together. And Paul Joffe, who has now disappeared under a table because I'm about to ask this question, said one thing, Senator, that I want to make sure that you don't do is to go in and ask about anything to do with shared research because there are all kinds of antitrust laws involving that and that would be a very bad thing to do. Having the high regard for Paul that I did, I went into the meeting and my first question is why aren't you people cooperating on your research so we can get something going together. And everybody turned sheet-white.

What was interesting to me, however—and I am not espousing that—that after I came out of the meeting, one of those three companies, two of their individuals came up to me, collared me and said, oh, God, we wish it were true, that we do not have enough brain power even in this very large automobile company, in fact, to apply the brains and the R&D to this problem that we feel that we need.

Comments.

Dr. **Bowditch**. Well, as you may know, Senator, we have been restricted from that type of operation by a consent decree which expired here within the last approximately year and a half. We are now able to begin to examine those kinds of things if we are very careful how we do it. And that is not out of the question at this point for our industries to get together as long as it is done very carefully. But we have not been able to do that until very recently.

Senator ROCKEFELLER. Was the fact of the clear and obvious Japanese interest in a flexible fuel vehicle, their pursuit of the same, their proximity to California which has 27 million people and God knows how many cars, some sort of incentive in making Detroit more receptive last year to the bill that was passed as opposed to the approach the year before when they were mostly negative? What caused the transition?

Dr. BOWDITCH. Now you are speaking the transition with respect to the plan?

Senator ROCKEFELLER. No, transition with regard to the bill, the methanol bill that passed. Detroit was resisting it in 1987, and they were supporting it in 1988. Why?

Dr. BOWDITCH. To my knowledge, we still remain technically advanced over the Japanese with regard to the use of methanol. Now, you may have better access to that information than I, Senator, but from what I know, the U.S. industry is further ahead in the development of methanol vehicles than are the Japanese.

With regard to the change in attitude, I think maybe the industry has realized the extent of the interest in methanol vehicles and, in effect, recognized the handwriting on the wall, if you like, and that we better get on with the problem of developing those vehicles. And as a result, we have come quite a ways in the development of such vehicles. We are not entirely there yet, but at least we have made great strides I believe.

Senator ROCKEFELLER. Thank you, sir, very much.

Mr. Yuhnke, what is your view on the question of whether the gasoline engine can be improved to obtain the same level of air quality benefits as can be obtained from alternative fuels?

Mr. YUHNKE. I think, Senator, at this point the work that has been done with alternative fuels is still sufficiently preliminary that I do not think anybody can say what the optimal performance is going to be with alternative fuels. So, we do not know what the end point of that process is, and it is very hard to judge whether or not gasoline will get you as far since we don't really know what the point is.

And I think our concern is that the kind of work that needs to be done to identify the optimal mix of technology from the manufacturers and fuel from various fuel sources is the kind of analysis that really hasn't been done on a competitive basis. And that is the kind of program that we think is necessary to answer your question. I do not think that anybody at this table today could with confidence feel comfortable answering that question, but what we need is a program that gets us that answer.

Senator ROCKEFELLER. In your prepared testimony, you state your opposition to alternative fuels based on coal.

Mr. YUHNKE. Yes, sir.

Senator ROCKEFELLER. You have reaffirmed that.

Mr. YUHNKE. And that is based on the analysis that has been done by a number of people in the environmental community. The most advanced piece of work was done by Jim McKensie at the World Resources Institute where they have done some calculations as to the CO_2 penalty that would be paid by the conversion of coal to methanol. And from a global warming standpoint, we do think that is unacceptable.

Senator ROCKEFELLER. I am going to get to that.

It was interesting to me that during the course of the passing of this bill that the environmental community—Chevron, for example, in their study, as I recall from a year or so ago, calculates that coal doesn't enter into the methanol mix, so to speak, until somewhere around 2050, which was sort of depressing news in West Virginia, for example. [Laughter.]

But clearly they do not think it is an immediate problem.

Mr. SMITH. Senator, excuse me. It is depressing for Chevron too because that is dependent on oil prices going up, and that says oil prices are going to be low for a long time into the future.

Senator ROCKEFELLER. So, it could be 2070.

Mr. SMITH. We certainly hope so.

Senator ROCKEFELLER. But now the environmental community consistently—and God, bless them. Bob Stafford and his top aide, Curtis Moore, were absolutely flat out against this whole thing based upon this horrible prospect that some day after years and years of benefit of natural gas—and I would hope, of course, it would be natural gas and then coal. You know, the technology would become available and it would become clean, and I think it has to be clean.

They opposed. And I did convince Mr. Stafford to ask for a voice vote, thank God, and he agreed. Thank God we are friends. But Curtis Moore kept saying no. If there is any coal anywhere there in the future, it has to be bad and, therefore, let's stop all of it now, including all of the benefits that might come from natural gas and other alternative fuels. We have to say no now because there might be coal in the future.

You have heard this before, but there was no synthetic rubber until the Japanese overtook us in Indonesia and the Philippines, and then there was synthetic rubber.

The automobile companies said there will be no catalytic converter. We can't do it. We don't have the technology. We don't have the brains. We don't have the money. And then when they were ordered to do it, it was done on 75 percent of American cars within a single year.

Now, give America some credit for brains.

And is it not just possible that somewhere there could be a technology that could be put together perhaps by Chevron or DuPont or Celanese or Eastman Kodak or Paul Joffe that makes clean coal methanol? Why was it that the environmental community was opposing the entire thing and all of the benefits between now and then based upon this reflexive fear discounting the possibility of technology?

Mr. YUHNKE. Senator, I am not going to presume to speak on behalf of all of my colleagues in the environmental community, but I want to point out that our testimony here today is not hostile to methanol. And as I pointed out earlier in my oral statement——

Senator ROCKEFELLER. Now it isn't because it is the law.

Mr. YUHNKE. No, I don't think that's the reason.

Senator ROCKEFELLER. Last year—well, okay.

Mr. YUHNKE. No, I know what happened to the law, and I understand the position that was taken by Dick Ayers in correspondence that came to the committee and other members. I saw that correspondence.

I think our position at EDF is that to the extent that we can make a fuel decision that is consistent with achieving global warming objectives, then that is fine. It doesn't matter particularly whether it is methanol or CNG.

Our point, though, is that those criteria for judgment which include both impacts on total CO_2 emissions and methane emissions need to be plugged into the process for determining whether or not a given fuel is to be treated as the preferred option. We are not objecting per se to methanol, and if it can be done in a way, as appears to be the case if methanol is made from natural gas, that it does give us some global warming benefit, then that is fine.

Now, along the way it may well be conceivable—and at the moment I can't conceive of it, but it could well be that somebody will come up with this kind of technological fix that you are talking about that would make it possible to convert coal to methanol without the CO_2 penalty.

And that is why our recommendation here is couched in terms of greenhouse gas standards that apply to the entire fuel cycle. We are not talking here about a standard that would apply at the tailpipe. We are talking about a standard that would apply across the entire range of the fuel cycle beginning with extraction from the ground, the production, the refining process, the transport process, and then combustion in the engine. And when you add up the total emissions of the two gases of concern, CO_2 and methane, and you use that as the basis for comparing entire fuel cycles, that we think is a logical approach to trying to identify the comparative benefits of different fuels.

And that is what we are asking for, a level playing field. Everybody has the opportunity to compete, but we have to make sure that the criteria chosen for the competition of who wins and who loses achieve environmental objectives that I think we probably all agree on.

Senator ROCKEFELLER. That is what I am looking for too is a level playing field.

Mr. YUHNKE. Right. And in our view at EDF, we are not trying to foreclose specific fuel options on that basis.

Senator ROCKEFELLER. Let me just take you through one final question. I know that time is running here and I apologize to everybody.

You did state your opposition to methanol based on coal.

Mr. YUHNKE. Based upon the current evidence that is available to us——

Senator ROCKEFELLER. That is all I'm saying.

Mr. YUHNKE. With that CO_2 penalty.

Senator ROCKEFELLER. Right. And you say that "to preclude the possibility of coal-derived methanol from entering the market, Congress should direct EPA to set fuel neutral emission standards for CO_2."

On the other hand, in its testimony the California Energy Commission says that production of methanol from coal in connection with production of electricity, "results in a net reduction of CO_2 when compared to an equivalent dedicated power plant burning coal and using an amount of gasoline equal in energy to the coal produced methanol." Of course the coal-derived methanol is not yet economic. We have agreed on that, all of us.

But why doesn't this show that it is possible even with no advance in technology to make coal derived from methanol compatible with CO_2 reduction?

Mr. YUHNKE. It could be. It may well be that one of the technological options is to generate both electric power and methanol, as the cool water technology that Southern Cal Edison has been demonstrating for the production of electric power out in California is capable of doing. EPRI is doing some work to look at that from the standpoint of using that technology to both generate power and use its byproduct to produce methanol.

Now, it is conceivable. I haven't looked at the analytical work that supports this. So, I don't know the answer. I do not want to be quoted as saying we support this necessarily, but it is conceivable that when you get a double hit out of that carbon atom, you can extract enough energy from it that you don't pay a CO_2 penalty, that you in fact maximize the energy benefits from that carbon atom in the coal in such a way that we are not going to have an adverse greenhouse impact.

But the standard that we are recommending would account for that because it is system-wide. It accounts for the entire fuel cycle. So, if you were able to develop this technology, that would be taken into account in terms of the way you would maximize the energy benefits from the coal. That is why we are making this recommendation. It allows exactly for that kind of analysis to look at technological options such as that as a way of resolving your concern.

Senator ROCKEFELLER. Just one final thought. If the country does decide to reduce CO_2 emissions, don't in fact you need—you and your group—to broaden your focus to include not just auto emissions but net emissions resulting in a situation where fuel and electricity are co-produced?

Mr. YUHNKE. And that is exactly what we are talking about, this entire fuel cycle emissions of these two greenhouse gases. So, to the extent that you are getting, as I said before, a double energy hit, that certainly counts as a benefit. It is to be analyzed though for the entire fuel cycle.

Senator ROCKEFELLER. One little exhibit here. You would agree that diesel buses are a serious air pollution problem, any diesel particles are highly carcinogenic. Your testimony indicates that "between 2 and 8 percent of the current non-smoker risk of contracting lung cancer in the U.S.' is caused by diesel particulate matter." You note that "diesel emissions are one of the most significant causes of environmentally induced cancer." I understand that particulate emissions can be substantially reduced with alternative fuels.

Now, I just have one little thing to say. The Texas Land Commissioner, Gary Morrow, who is a leader on alternative fuels, was kind enough to provide the committee with an exhibit that is pertinent I think to our hearing. There being no cameras here—it doesn't matter.

I have here in my hand a bottle that contains five minutes worth of particulate emissions from a typical diesel engine. This is 5 minutes worth. Mr. Morrow points out that when you shake this bottle, you see what looks like a couple of inches of black soot. Actually it is very fine particles which hang in the air and circulate for a very long time.

Mr. YUHNKE. It is a very graphic demonstration.

Senator ROCKEFELLER. Don't you think it is quite dramatic?

Mr. YUHNKE. Very.

Senator ROCKEFELLER. Methanol has a place in buses?

Mr. YUHNKE. Well, keep in mind, though, that the data are mixed because we are seeing a dramatic improvement in that pollutant, but then we are also seeing a 100-fold increase in carbon monoxide emissions and a 40-fold increase in hydrocarbons. And what we need to do is see whether or not we can reduce those emissions down to levels that are comparable to diesel so that we can get an actual net benefit. We do not want to be trading off pollutants, making one better because we know that is a problem——

Senator ROCKEFELLER. New buses?

Mr. YUHNKE. These are the six methanol buses that are being operated by Tri-Borough Coach in New York on methanol. These are the ones that were designed specifically for the test run of the diesels on the street in commercial service. And those test results are giving us mixed results.

For nitrogen oxides and particulates, we are seeing definite improvements in performance. And that is very encouraging. It is that kind of emission improvement that gives us a lot of hope that these fuels, in fact, can make a big difference in the urban environment. But we do not want to get in the situation where we are playing this tradeoff game.

Senator ROCKEFELLER. I am told that some of these new buses in New York and California produce substantially better results than you seem to be indicating. We will leave that for the record to reflect on.

And I thank you very much for your presence.

Mr. Back, again I apologize to you and to other witnesses following because of the length of this which I do not regret, but I apologize for the inconvenience.

What got you interested in methanol buses?

Mr. BACK. Well, the fact of the matter is again it gets back to the environment that we have in our area with the coal production and the chemical industry and the concerns with the clean air, the EPA regulations that we are faced with. All of these factors combined had a great deal of influence along with the encouragement of our congressional delegation and local elected officials who are interested in the development of the coal technology to produce methanol.

Senator ROCKEFELLER. And you think that these could be of benefit to West Virginia.

Mr. BACK. Oh, there is no question about it. It may be long-term as we have been discussing.

I do not have the document with me, but I received a document as a result of my name being on a list I guess to testify here that technology is being tested in Germany I believe that does have a capability of manufacturing methanol from coal cleanly as compared to the process even of manufacturing from natural gas. I cannot speak to that with any authority. Again, I just read the document and it is laying on my desk.

But long-term it has a tremendous potential impact on the State of West Virginia, not that there is that much that we will use ourselves there, but West Virginia, if this technology is developed, could be one of the prime producers of methanol in this country. And we could be supplying nationally methanol from our coal as opposed to the need to import the methanol from other countries.

Senator ROCKEFELLER. It would be nice, wouldn't it?

Mr. BACK. It certainly would.

Senator ROCKEFELLER. If you obtain the UMTA funding which you are seeking which is what? About $15 million?

Mr. BACK. Yes, $15 million.

Senator ROCKEFELLER. What expenses will that money go for that you would not have had for conventional buses?

Mr. BACK. Of course, the methanol buses are included in that. This is part of an overall comprehensive statewide program to meet the capital needs of all the transit systems in the state. But I think the inclusion of the methanol buses has given it priority at all levels, including UMTA, for the funding.

Without that program, the transit systems in the State of West Virginia face a very bleak future with the capability of maintaining our capital equipment to current standards. It is absolutely essential that we have that program. And right now it is looking very good for us.

Senator ROCKEFELLER. And I hope it works out that way. I really do.

Mr. BACK. I believe it will.

Senator ROCKEFELLER. Gentlemen, I again apologize for keeping you all so long. These hearings are important because we do get things on the record, and building the record is important, as you know, in legislation. So, I am very, very grateful to all of you and appreciate your patience.

I would now ask Dr. John Berg who is the Assistant Secretary for Conservation and Renewable Energy—we have a vote. I'm sorry. An additional seven minute recess.

[Recess.]

Senator ROCKEFELLER. Dr. Berg, I welcome you, sir, and I welcome your testimony. And you may proceed.

STATEMENT OF DR. JOHN R. BERG, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY

Dr. BERG. Thank you very much, Mr. Chairman. First let me thank you and the members of the subcommittee and the staff and the other people that have testified here today for trying to accede to our changing schedule. We really appreciate your trying to accommodate us, sir.

I have a statement which I would like to submit for the record and summarize it for you orally, if I may.

Senator ROCKEFELLER. Yes, please.

Dr. **Berg**. With me today by a number of people from the Department of Energy: Mr. Reid Detchon, my Principal Deputy Assistant Secretary for Conservation and Renewable Energy; the Deputy Assistant Secretary for Conservation, Mr. Alan Streb; and the Deputy Assistant Secretary for Renewable Energy, Dr. Robert San Martin, plus several other members as well.

I am happy to have this opportunity to appear before you and the subcommittee today to discuss the future of alternative motor fuels and various legislative options to promote their use.

I want to emphasize the importance to the Nation of reducing our reliance on imported petroleum whenever we can do this in a way that makes sound economic sense. Alternative fuels have the potential to contribute to such reductions.

The transportation sector plays a crucial role in United States petroleum dependence. Oil used by the transportation sector in 1988 was almost 11 million barrels per day, up about 4 percent from 1987 and almost 20 percent higher than in 1973. Transportation oil use alone exceeded the United States production of crude oil in 1988 by 2.8 million barrels per day.

Alternative fuels such as methanol, ethanol, compressed natural gas, liquified petroleum gas and electricity may have the potential to enhance our energy security by increasing both our technical options and our market options in the sometimes volatile world energy markets. Once technical and economic efficiency are established, fuel flexible and dual-fueled vehicles would give consumers the chance to choose among competing fuels.

The extent of the energy security benefits of alternative fuels will depend on the likely sources of supply. These benefits are greatest when alternative fuels are produced domestically. However, the energy security benefits would be diminished if the alternative fuels are imported from areas that are unstable or unreliable. And, unfortunately, this could be the case.

In 1987 the Department started a comprehensive assessment of the Costs and Benefits of Flexible and Alternative Fuel Use in the United States Transportation Sector. This assessment has focused on the changes to vehicles and the fuel distribution infrastructure required to use alternative fuels, the cost and likely sources of supply of alternative fuels, and any potential safety and environmental problems which alternative fuel use may pose. We have released several reports on the progress of this study and will be releasing two more reports shortly. These reports and assessments will provide additional information for more informed policy decisions.

While DOE is looking at alternative fuels largely from an energy security perspective, we recognize that much of the driving force behind the current interest is due to environmental concerns. Alternative fuels have the potential to mitigate ozone pollution and, to reduce carbon monoxide and carbon dioxide emissions, depending upon how they are used and the source of the fuel. EPA is conducting studies to define these benefits and determine whether alternative fuels will be economically competitive and are a cost-effective air quality strategy. We are continuing to work with EPA to ensure that the appropriate data are available on which to make these judgments and to ensure that energy and environmental concerns are balanced.

Let me now turn to the Department's implementation of the Alternative Motor Fuels Act of 1988. We are moving rapidly to carry out the intent of Congress expressed in this legislation even, in the absence of an actual appropriation of funds, which will not be available until October of 1989. We believe that the Act provides a prudent structure and process in which to properly examine alternative transportation fuels. This Act has specific provisions that affect corporate average fuel economy standards, Federal purchase of alternative fuel vehicles and development of heavy duty alternative fuel vehicles.

The Secretary recently named Henson Moore, Deputy Secretary of Energy, to be the Chairman of the Interagency Alternative Fuels Commission, created pursuant to that statute. By appointing Deputy Secretary Moore to this position, Secretary Watkins intended to convey the importance that the Department of Energy attaches to the work of the Commission, which will have the responsibility for coordinating the alternative fuels activities of the Federal Government.

The most important mission assigned to this Commission is to develop and implement a national alternative motor fuels policy. The Department is moving ahead rapidly to carry out the intent of Congress expressed in this legislation.

We are also in the process of selecting members of the U.S. Alternative Fuels Council, which the legislation established to provide advice to the Commission. And, as you are aware, you, sir, have been appointed by the Senate Majority Leader, and we welcome you to that commission. And Congressman Alexander has been appointed by the Speaker of the House. We are looking forward to being notified of the other appointments.

We have been asked to comment on specific proposals to promote alternative motor fuels. Such proposals should and will be evaluated by the Interagency Commission with the assistance of the Advisory Council, and we feel that it would be inappropriate to comment before these two Congressionally mandated bodies have even met once. In addition, the subject of alternative fuels is currently before the President in the context of the Clean Air Act.

The introduction and use of alternative transportation fuels can have important energy security and environmental implications. It will certainly have significant consequences for substantial segments of the United States economy, for several critical industries and for consumers. We will need to proceed on this issue with care. The investment that would be required and put at risk to modify transportation's reliance on oil will be measured in tens of billions of dollars. We will need to develop confidence that this level of investment will be translated into meaningful and positive benefits for the Nation.

Because of these ongoing considerations, we are not prepared to support new legislative initiatives at this time. However, we believe that we have the means and certainly the will to fully carry out the provisions of current legislation.

This concludes my remarks, and I would be happy to answer any questions that you or the committee may have.

[The prepared statement of Dr. Berg follows:]

STATEMENT

OF

DR. JOHN R. BERG

ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

UNITED STATES SENATE

JUNE 8, 1989

I am happy to have the opportunity to appear before this Subcommittee today to discuss the future of alternative motor fuels and various legislative options to promote their use.

I want to emphasize the importance to the Nation of reducing our reliance on imported petroleum whenever we can do this in a way that makes sound economic sense. Oil consumption is increasing, and domestic production is in decline. We are concerned about the problems this causes for the domestic industry. We must address any problems this poses for the country.

Total U.S. oil use increased by over half a million barrels per day last year and continues to grow. Domestic crude oil production has declined from a 1985 high of 9 mmB/D to 8.1 mmB/D in 1988. The combined effects of increased consumption and declining production raised oil imports for 1988 to 7.4 mmB/D. Imports from OPEC countries have supplied a large fraction of that increase.

From a low of 1.8 mmB/D in 1985, imports from OPEC countries grew to 3.5 mmB/D last year. We are on a course that will lead in the early 1990s to historically high levels of oil consumption and imports reaching 50 percent of national requirements. We recognize, of course, that we cannot achieve energy security by simply reducing imports; we must reduce imports in an economically sensible way. Alternative fuels have the potential to contribute to such reductions.

The transportation sector plays a crucial role in U.S. petroleum dependence. Oil use by the transportation sector in 1988 was almost 11 mmB/D, up about 4 percent from 1987, and almost 20 percent higher than in 1973. Transportation oil use alone exceeded U.S. production of crude oil in 1988 by 2.8 million barrels per day.

Because transportation's near total dependence on oil is not expected to change, even with higher fuel efficiency, the Department of Energy also has focused its attention on alternative transportation fuels. Alternative fuels such as methanol, ethanol, compressed natural gas and electricity may have the potential to enhance our energy security by increasing both our technical options and our market options in the sometimes volatile world energy markets. Once technical and economical efficiency are established, fuel flexible and dual-fueled vehicles would give consumers the chance to choose among competing fuels. Other sectors of the economy have benefitted from this flexibility. But, transportation remains dependent on oil because alternative fuel capable vehicles are not currently a competitive presence in the marketplace.

The extent of the energy security benefits of alternative fuels will depend on the likely sources of supply. These benefits are greatest when alternative fuels are produced domestically. However, the energy security benefits would be diminished if the alternative fuels are imported from areas that are unstable or unreliable. Unfortunately, this could be the case. In evaluating potential large scale sources of natural gas for fuel methanol, it should be recognized that most of the world's proved reserves are found in the Soviet Union (43 percent) and the Middle East (26 percent), and these areas had the most reserve additions during the 1980s. DOE analysis to date indicates that Africa and the Middle East are the regions with significant potential for methanol export to North America and Western European markets. In addition, there is also gas available that is currently being flared or reinjected outside the Soviet Union and the Middle East. The economics of all these supplies of natural gas is uncertain at this point.

In 1987, the Department started a comprehensive Assessment of the Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector. This assessment has focused on the changes to vehicles and the fuel distribution infrastructure required to use alternative fuels, the cost and likely sources of supply of alternative fuels, and any potential safety and environmental problems which alternative fuel use may pose. We have released several reports on the progress of this study and will be releasing two more reports shortly. These reports and assessments will provide additional information for more informed policy decisions.

While DOE is looking at alternative fuels largely from an energy security perspective, we recognize that much of the driving force behind the current interest is due to environmental concerns. Alternative fuels have the potential to mitigate ozone pollution, and reduce CO and CO_2 emissions, depending on how they are used and the source of the fuel. EPA is conducting studies to define these benefits and determine whether alternative fuels will be economically competitive and are a cost-effective air quality strategy. We are continuing to work with EPA to ensure that the appropriate data are available on which to make these judgments and to ensure that energy and environmental concerns are balanced.

Let me now turn to the Department's implementation of the Alternative Motor Fuels Act of 1988. We are moving rapidly to carry out the intent of Congress expressed in this legislation, even in the absence of an actual appropriation of funds which will not be available until October, 1989. We believe that the Act provides a prudent structure and process in which to properly examine alternative transportation fuels. This Act has specific provisions that affect corporate average fuel economy (CAFE) standards, Federal purchase of alternative fuel vehicles, and development of heavy duty alternative fuel vehicles.

The Secretary recently named Henson Moore, Deputy Secretary of Energy, to be the Chairman of the Interagency Alternative Fuels Commission created pursuant to that statute. By appointing Deputy Secretary Moore to this position, Secretary Watkins intended to convey the importance that the Department of Energy attaches to the work of the Commission, which will have the responsibility for coordinating the alternative fuels activities of the Federal Government.

The most important mission assigned to this Commission is to develop and implement a national alternative motor fuels policy. The Department is moving ahead rapidly to carry out the intent of Congress expressed in this legislation.

There are a number of issues - economic, technological and policy - that the Commission will need to consider. For some of these we have answers; for others, additional work will be needed before decisions can be made.

We are also in the process of selecting members of the U.S. Alternative Fuels Council, which the legislation established to provide advice to the Commission. As you are aware, Mr. Chairman, the Council also includes four members appointed by Congress. Senator Rockefeller has been appointed by the Senate Majority Leader and Congressman Alexander has been appointed by the Speaker of the House. We look forward to being notified of the other appointments.

We have been asked to comment on specific proposals to promote alternative motor fuels. We are aware of legislation recently introduced in the House by Congressman Andrews of Texas to provide tax incentives for clean-burning motor vehicles. We have also reviewed a report by the Congressional Research Service containing many specific recommendations for action on this issue. These proposals, along with others, should and will be evaluated by the Interagency Commission, with the assistance of the Advisory Council, and it would be inappropriate to comment before these two congressionally mandated bodies have met even once. In addition, the subject of alternative fuels is currently before the President in the context of the Clean Air Act.

The introduction and use of alternative transportation fuels can have important energy security and environmental implications. It will certainly have significant consequences for substantial segments of the U.S. economy, for several critical industries, and for consumers. We will need to proceed on this issue with care. The investment that would be required and put at risk to modify transportation's reliance on oil will be measured in tens of billions of dollars. We will need to develop confidence that this level of investment will be translated into meaningful and positive benefits for the Nation.

CONCLUSION

Past achievements in increased domestic energy production, fuel substitution, and greater energy efficiency have brought us the benefits of lower prices and abundant oil supplies. But shrinking domestic production, expanding demand, and growing import dependence have heightened interest in the economic potential of conservation and alternative energy sources.

As noted above, import percentages, per se, are an imperfect measure of energy security. Nonetheless, the transportation sector, because of its reliance on petroleum-based fuels and because of the size of its oil consumption, is widely regarded as a key element in addressing our energy security concerns. Increased use of alternative transportation fuels, when economically competitive, will need to be a part of a national strategy to mitigate the projected growth in petroleum demand. I would emphasize, however, that alternative fuels should not be viewed as the only potential ways to deal with energy security. The introduction of competitive alternatives to petroleum in the marketplace would take a considerable amount of time to accomplish. During this time, U.S. oil use and oil imports are expected to rise. While we view alternative fuels, when they prove competitive, as forming part of our strategy to render our transportation sector fuel-flexible, we must concurrently pursue other policies that will restore the economic health and productivity of our domestic energy sector. All of this must be done in a way which strengthens the overall economy, avoids government intervention that could be counterproductive, and enhances our international competitiveness.

The Interagency Commission on Alternative Motor Fuels will pursue an agenda that will assess the benefits and costs of alternative fuels and their impact on our economic competitiveness. The President is also currently reviewing the role alternative fuels might play in achieving the Clean Air Act objectives. Because of these ongoing considerations, we are not prepared to support new legislative initiatives at this time. However, we believe that we have the means, and certainly the will, to fully carry out the provisions of the current legislation.

This concludes my prepared remarks. I would be happy to entertain any quastions that the Committee may have.

Senator **Rockefeller**. You know, Dr. Berg, I am really puzzled by your testimony. I understand that the President is going to be making announcements on various things on Monday and that you do not want to preempt him or the specifics of the proposal. But as I said in my opening statement, as I assume that you know, there is a lot more at stake here than just the specifics of clean air legislation.

Frankly, as I read your testimony which you did, you seem in my view lukewarm with respect to alternative fuels. I hope I am wrong. And I hope that you will talk me out of that interpretation. I want to give you some examples.

You say that alternative fuels have potential to mitigate ozone and that EPA is conducting studies. The fact of the matter is EPA is considerably farther along than just conducting studies. EPA announced over a year ago that cities can take substantial credits toward ozone requirements for use of alternative fuels. EPA testified last month before this committee, Senator Bingaman's subcommittee, that very substantial air quality benefits come from alternative fuels. They have said that.

You also seem doubtful about the energy security benefits of alternative fuels which seems at odds with prior statements of your Department, DOE, which I will get into in a moment.

Further, you say that DOE is studying various issues relating to the economics of alternative fuels, but you do not tell us what you are finding.

I spoke to the Society of Automotive Engineers, and after that Mr. Joffe at my right stayed and DOE was openly discussing what they were finding. That was 2 months ago. These are not secrets.

For example, I gather you have found that the cost of producing methanol would be significantly lowered by economies of scale. That is fairly important stuff. Anything wrong with telling us that?

Frankly, I am puzzled by your statement that because Congress established an interagency commission which, yes, I happen to be on, that it would be inappropriate, as you say, to comment before the commission has met on proposals regarding alternative fuels legislation. I can't believe that you mean that. You can't mean that it is inappropriate for the Department of Energy to answer an inquiry from a congressional committee on its views about legislation. You can't comment on the legislation you say. Here is the Department of Energy. The boss says too much time. We have to act now. Time is slipping by. We have a problem. We have an emergency.

Now, you may have other views, and maybe I have misinterpreted your testimony. But I would be happy to be corrected, to be reassured that you care a lot more than you appear to. This testimony doesn't say anything. It's nothing. It's just an empty thing. Do you want to respond to that?

Dr. **Berg**. First of all, let me state that we are working on a number of areas you are fully aware of with alternative fuels. We think there is potential there, very much so. In fact, we are looking forward to doing the studies in which we will be working with fleets of vehicles—and when we say fleets of vehicles, these are light vehicles. We are also talking about the bus and the heavy trucks—that will be tested using alternative fuels over a period of years and data will be collected and analyzed.

You are also well aware, I believe, that we have sponsored, along with the Society of Automotive Engineers and General Motors and others, the recent alternative methanol fuel race that involved 15 universities, the University of West Virginia being one of the group. Students were challenged to take standard General Motors Corsica Chevrolet cars and to convert these to M85 fuel——

Senator ROCKEFELLER. Right, and it was done and it was wonderful.

Dr. BERG. Just like the Indianapolis Speedway, sir, those are geared to run a race and to complete it. The important thing now is to win the big race. The big race is driving 100,000 miles with those vehicles and see how they do, and see what the emissions are and see where we stand.

Senator ROCKEFELLER. Do you think that we have to have an aggressive policy toward alternative fuels in this country?

Dr. BERG. I think this is something that you as a member of the council and the commission——

Senator ROCKEFELLER. I can't believe you are saying that.

Dr. BERG. We do not want to usurp something that you, as Congress, have already asked us to do. We want to work together with you, and to look at the alternatives and to see what the various options are and to get these studies in front of you where you can make good, valid decisions.

Senator ROCKEFELLER. You are waiting for the commission. You consider the commission to be the almighty—this council. I can't believe this. You can't make recommendations to us. You have to wait till we meet.

Dr. BERG. I think what you have done and are doing is really great. You have opened up dialogue. You have these people thinking.

Senator ROCKEFELLER. What people thinking?

Dr. BERG. Everyone in industry—and that includes petroleum, coal biofuels and the rest—on how they can answer and solve these problems that are facing the United States right now.

Senator ROCKEFELLER. What do you think ought to be done about solving these problems? Your title is Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy. What do you think should be done?

Dr. BERG. I think we should continue our research and development to pursue those areas that will reduce the dependence on foreign oil and will increase the benefits to the environment. And when I say that, I am saying that I think that ultimately we will be moving toward a fuel derived from biofuels.

Senator ROCKEFELLER. You know President Bush is very strongly for alternative fuels?

Dr. BERG. Yes, sir.

Senator ROCKEFELLER. Watkins says there is a big crisis. We have to move fast.

Dr. BERG. I want to move rapidly, but I do not want a move which could cause us greater harm than what we may have by cleaning up—right now you have the petroleum industry coming in and saying that they think they can clean up motor vehicle fuels. I think that is great. One wonders where they have been for a number of years, but at least now people are starting to concentrate on some of these problems.

Senator ROCKEFELLER. Is there anything that says that the Department of Energy has to wait for the commission in order to come up with recommendations?

Dr. BERG. We are working on our research, sir, both in the area of clean coals, fossils, and in renewable areas, to answer some of the questions that will make them cost competitive. If solved they may produce a better, cleaner atmosphere, and they would be competitive with oil.

Senator ROCKEFELLER. We are talking about putting Americans back to work in agriculture. We are talking about putting Americans back to work in natural gas. We are talking about putting Americans back to work in coal mines. We are talking about energy security. We are talking about cleaning up lower ozone. We are talking about the Clean Air Act. EPA could come down on 60 American cities tomorrow and shut them down.

And you are saying that we are studying all of this, and you are the Department of Energy. I don't understand. What am I missing?

Dr. BERG. We are working toward an integrated national energy policy.

Senator ROCKEFELLER. But you are waiting on us.

Dr. BERG. No.

Senator ROCKEFELLER. We have to be the ones.

Dr. BERG. No, we are not waiting on you. You will be part of the input.

At the present time, we are not prepared to say that this should be the way we go. We can say that these seem to be ways that ought to be investigated, but to say that this is going to be the way it should be done yet, we are not prepared to do that, sir.

Senator ROCKEFELLER. Okay.

You have under way several major studies on the economics of methanol production and distribution. You have indicated tentative findings of the cost of producing methanol can be substantially lowered through economies of scale. You are indicating that the cost of infrastructure is significant, but relatively modest compared to our national energy expenditures.

Are you prepared to tell us the steps that can be taken to reduce costs further to develop production and infrastructure? Do you have thoughts as to some of those matters?

Dr. BERG. Yes, sir. We have under study areas that would reduce the cost of producing methanol from coal. We have research going on that has shown great promise in reducing the cost of producing methanol, ethanol and other synthetic fuels from plant material, the biofuels.

Senator ROCKEFELLER. In 1980 Congress passed a law requiring DOE to submit a plan to Congress for displacing 10 percent of our gasoline with alcohol fuel by the year 1990. Where are those plans?

Dr. BERG. I will have to ask.

[Pause.]

Dr. BERG. We will answer that for the record, sir.

Senator ROCKEFELLER. I can answer. They are long forgotten. They are long forgotten.

I do not want to continue.

I think Admiral Watkins is superb, and he has made a tremendous impact on this Government already. He was crucial, for example, in the FSX decision just because people respect him. I think he is absolutely superb.

He has indicated there is an emergency here. There is a crisis.

And Henson Moore was meant to come. We changed this, as you indicated, to accommodate him. He didn't. You came. We got this at 6:00 p.m. last night. And I do not find anything in it. I am your friend. I really admire the President for his support of this. I am reaching out to you saying get off the dime on this.

Dr. **Berg**. In reply, sir, I would say that we are more than willing to meet you halfway on this and will. We want you on the council and we respect your input on that council. Outside of that, as you are well aware of and have been briefed, or at least Mr. Joffee and the other members of your staff have been briefed, we are moving forward in this area.

At this point we cannot, though, give you a specific direction—one particular direction that we want to go.

Senator **Rockefeller**. Okay, and I accept that and I respect your views on it, Dr. Berg. And I thank you very, very much.

Dr. **Berg**. Thank you very much.

Senator **Rockefeller**. Our final panel, noble souls all, Dr. George Roberts who is General Manager of Commercial Development Division, Air Products and Chemicals, Inc., from Allentown, Pennsylvania; Mr. Robert Reynolds, President, Downstream Alternatives, Incorporated, from Indiana; and Mr. Elwin Larson, President and CEO, Brooklyn Union Gas Company.

Mr. Reynolds is not here. His statement has been put in the record.

And Mr. Larson is speaking on behalf of the American Gas Association and Natural Gas Coalition. Mr. Larson, I welcome you, sir, and look forward to your testimony.

STATEMENT OF ELWIN S. LARSON, PRESIDENT AND CHIEF OPERATING OFFICER, BROOKLYN UNION GAS CO., ON BEHALF OF THE AMERICAN GAS ASSOCIATION AND THE NATURAL GAS VEHICLE COALITION

Mr. **Larson**. Thank you very much.

Good afternoon. As you have already mentioned, my name is Elwin Larson, and I am President and Chief Executive Officer of the Brooklyn Union Gas Company. However, I am appearing here today on behalf of the American Gas Association and the Natural Gas Vehicle Coalition of which I am the Chairman.

My written testimony discusses in substantial detail the overall environmental, energy security and economic contributions that natural gas vehicles, or NGV's, can make to this country if their use becomes more widespread. Rather than repeat what is in my written statement, I would like to concentrate my remarks on the significant air quality improvements that could be realized through widespread use of NGV's and the need for stronger Federal policies to promote clean air vehicles.

The most recent EPA data available shows that 81 metropolitan areas experienced peaks that were out of compliance for ozone in 1987 and 31 metropolitan areas were similarly out of compliance for carbon monoxide.

As compared to gasoline or diesel vehicles, natural gas vehicles can reduce emissions of reactive hydrocarbons, a critical element in the formation of ozone, by 80 percent or more. Reductions of carbon monoxide emissions of approximately 85 percent can be achieved and in the CO_2 area, a reduction of 18 to 30 percent. These reduced emissions are for vehicles dedicated to natural gas use.

Significant environmental benefits can be achieved by converting vehicles to natural gas. For example, such conversions can result in reductions in emissions of oxides of nitrogen of 65 percent or more. However, because factory built dedicated vehicles can make optimal use of the properties of natural gas, such vehicles would maximize the efficiency of natural gas and represent the greatest benefit in the longer term.

The full benefit of NGVs and other clean vehicles can only be obtained by putting more of these vehicles on the road. And we call upon Congress and the administration to launch a bold initiative to promote the use of clean vehicles. Such an initiative should be fuel neutral allowing for alternative fuels and vehicles to compete on an even footing.

We believe that last year's Alternative Motor Fuels Act provided a good foundation for a comprehensive clean vehicle policy. And we commend the Senator and the other sponsors of the Alternative Motor Fuels Act for their leadership and insight. The act's provisions should stimulate greater use of clean vehicles, especially in the Federal fleet. I stress that the potential benefits of this law will not be achieved, however, unless Congress appropriates the funds authorized by the law.

The Alternative Motor Fuels Act was a good beginning, but much more is needed if we are to obtain the full benefits of clean fuels. If it is good public policy to clean up the environment—and we believe that it is—legislation should be put in place to provide incentives to help bring about alternative fuel opportunity and create a regulatory climate conducive to this change.

I believe an environmental assessment should be imposed on all fuels that pollute with an exemption for clean-burning fuels. However, I should point out this is my own personal view and that of the Natural Gas Vehicle Coalition.

Senator **Rockefeller**. It is your personal view and "that" or "not"?

Mr. **Larson**. And that of the Natural Gas Vehicle Coalition.

We also recommend that the Federal Government mandate fleet purchases of NGV's or other alternative fuels vehicles in areas that do not comply with the Clean Air Act standards for air quality. Bills introduced in this Congress by Senator Bingaman and Representative Fazio take this approach for ozone and carbon monoxide nonattainment areas.

Also, EPA's total hydrocarbon emissions standard, which has the potential to exclude NGV's from the market, should be modified to measure reactive hydrocarbons which contribute to ozone pollution.

As much as 80 percent or more of the hydrocarbon emissions from NGV's are nonreactive.

We also recommend that Congress adopt tax policies that provide incentives favoring clean vehicles by reducing capital cost barriers in connection with the vehicles and refueling stations. Policies providing reimbursement of capital costs and other incentives for vehicle conversions and refueling stations should be provided.

Other Federal actions should include amending the Clean Air Act anti-tampering provisions so that conversions to NGVs would not invite sanctions from EPA.

Senator ROCKEFELLER. Can you explain the anti-tampering to me please?

Mr. LARSON. Well, there are actually two problems here. One is that, as I understand is, the present law is that if modify the vehicle, the warranties do not apply. That is one problem.

And I believe there is a problem with sanctions from EPA, and I am not specifically sure how that operates. But it is written into the law. It is a quirk in the law as it was written. I can furnish you with more specifics on that if you wish. I do not have that specific.

These actions should not be adopted piecemeal or they will not be effective. Indeed, they should be considered an important environmental policy package that will help to rectify our air quality problems in the short term and ensure a long-lasting and healthy environment for our children.

Thank you very much. I appreciate the opportunity to appear here.

[The prepared statement of Mr. Larson follows:]

WRITTEN TESTIMONY OF

ELWIN S. LARSON

PRESIDENT AND CHIEF EXECUTIVE OFFICER

THE BROOKLYN UNION GAS COMPANY

REPRESENTING THE AMERICAN GAS ASSOCIATION AND

THE NATURAL GAS VEHICLE COALITION

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE ON

THE EXPANDED USE OF

ALTERNATIVE MOTOR VEHICLE FUELS

JUNE 8, 1989

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EXECUTIVE SUMMARY

o Natural gas vehicles (NGVs) can provide major reductions in tailpipe and other emissions.

-- Emissions of both reactive hydrocarbons and carbon monoxide from NGVs can be reduced by over 80 percent, compared to gasoline vehicles.

-- The Environmental Protection Agency estimates that fueling NGVs can reduce emissions of reactive hydrocarbons by 100 percent from filling stations and evaporation.

-- Natural gas can also be effective in meeting new EPA standards for heavy duty engines. When they were tested by EPA, two newly manufactured natural gas buses, now being operated in New York City, met or surpassed all heavy duty engine standards.

-- Natural gas can also reduce substantially tailpipe emissions of carbon dioxide, which is thought to be the leading factor in the Greenhouse Effect.

o There are ample domestic gas supplies to support greatly expanded use of NGVs.

-- A March 1987 Department of Energy report states that America may have enough natural gas to last 200 years or more. A May 1988 DOE study indicates that the equivalent of a 62-year supply of gas is technologically recoverable in the lower 48 States alone (without including Canada, Mexico, Alaska or unconventional domestic gas sources).

-- A November 1988 study by two former high-ranking DOE officials, William Martin and Scott Campbell, indicates that national natural gas consumption could be increased greatly without causing significant marketplace disruptions. The study finds that U.S. gas demand could rise from the 1987 level of 17.1 trillion cubic feet (Tcf) to a new level of 24.1 Tcf in 2010.

-- Assuming that by 2010 natural gas meets transportation fuel needs for 5% of the mass passenger vehicle market, 25% of the public and private fleet vehicle market, and 75% of the commercial bus market, the same study estimates that total NGV demand would be 1.7 Tcf. This is less than 10% of nationwide gas consumption in 1987.

o New federal air quality legislation should include the following: mandates for fleet shifts to clean vehicles; establishment of a reactive hydrocarbon standard at EPA; adoption of federal tax policies to reduce capital cost barriers to vehicles that use clean-burning fuels; revision of EPA's anti-tampering regulations so that they clearly permit retrofitting work on NGVs; supporting new technologies that advance or assist the growth and encouragement of the sale of alternative fuels by altered regulation of utilities; federal emission standards for all alternative fuels; elimination of regulatory uncertainty; and expanded federal assistance for research and development.

INTRODUCTION

The American Gas Association (A.G.A.) is a national trade association composed of some 250 natural gas distribution and transmission companies serving over 166 million natural gas consumers throughout the United States. The Natural Gas Vehicle (NGV) Coalition is made up of 59 members, including natural gas distribution companies, pipelines, producers, automotive equipment and vehicle manufacturers, natural gas vehicle users, environmental organizations, educational institutions, and other organizations interested in commercializing natural gas as a vehicle fuel. The NGV Coalition is dedicated to promoting and stimulating the use of natural gas as a vehicle fuel, supporting the development and implementation of federal and state policies that encourage the use of natural gas as a vehicle fuel and commercialization of the natural gas vehicle market and the natural gas vehicle industry.

A.G.A. and the NGV Coalition appreciate the opportunity to comment on federal government actions that may expand the use of alternative fuels in the U.S. transportation market. The Alternative Motor Fuels Act of 1988 was an important step toward providing manufacturers with an incentive to produce alternative fuel vehicles and stimulating demand for such vehicles. We believe this law provides an important foundation on which to improve air quality by promoting the expanded use of NGVs and other alternative fuel vehicles. NGVs can deliver important benefits to the American people, and we have the gas supplies to fuel those vehicles. As mandates and incentives are initiated at both the state and federal levels, NGVs should be allowed to compete with other alternative-fuel vehicles on a level playing field.

In August of 1988, the Department of Energy released "Progress Report Two: The International Experience" as the second volume of its multi-volume study, Assessment of Costs and Benefits of Flexible and Alternative Fuel Use in the U.S. Transportation Sector.

This DOE study surveyed the actual experience with alternative-fuel vehicles in several different countries that are pioneers in the field.

The DOE study shows that, of all the alternative-fuel vehicles being used throughout the world, more than half are running on gaseous energy.

Our testimony will show that this is no accident. Natural gas vehicles offer a wide range of benefits for their customers and for the public in general. It is no wonder they are popular.

Natural gas vehicles can be popular in this country, too -- _if_ public policy decision-makers will include them in air quality planning _and_ permit them to compete on their own merits against other alternative-fuel vehicles.

AIR QUALITY BENEFITS OF NATURAL GAS VEHICLES (NGVs)

EPA Estimates of Emission Reductions From NGVs

On January 28, 1988, the Environmental Protection Agency issued a Technical Guidance Document, suitable for use by state and local governments in estimating the actual impact of various air quality improvement options. The document, entitled _Technical Report: Guidance on Estimating Motor Vehicle Emissions From the Use of Alternative Fuels and Fuel Blends_, estimates that NGVs can yield the following emission reductions:

A 50% reduction in tailpipe emissions of carbon monoxide

A 40% reduction in tailpipe emissions of reactive hydrocarbons

A 100% reduction in emissions of reactive hydrocarbons from filling stations and evaporation

We note that EPA views its estimates as advisory rather than mandatory. That is, EPA permits states and localities to use their own estimates, in place of EPA estimates, where states and localities can show it is reasonable to do so. This point is particularly important because, in the gas industry's view, EPA has been conservative in estimating the achievable emission reductions from shifts to NGVs.

Estimates of Emission Reductions From NGVs

A.G.A. and the NGV Coalition regard EPA's estimates as conservative. Our estimates, based on gas industry experience, show that even more dramatic reductions are achievable for carbon monoxide and reactive hydrocarbons. As compared to gasoline vehicles, natural gas vehicles offer major reductions in emissions of carbon monoxide and reactive hydrocarbons.

So far, nearly all natural gas vehicles on the road are conversions of existing vehicles that once relied solely on gasoline or diesel fuel. Our experience with such vehicles indicates that, when proper procedures are used to convert older gasoline or diesel fuel vehicles to natural gas, such conversions can reduce emissions of carbon monoxide and reactive hydrocarbons by more than 80 percent.

The actual emission reductions achieved depend on a large number of factors, including the tuning of both engines, the age and design of both vehicles and the condition and technology of the gasoline emission controls and the natural gas conversion equipment. Despite these possible variations, however, the emission reductions will be significant so long as proper procedures and equipment are employed.

Even compared to vehicles that employ new gasoline technology, NGVs can achieve significant reductions of emissions. A.G.A. and the NGV Coalition estimate that carbon monoxide could be reduced by up to 82 percent and reactive hydrocarbons could be reduced by up to 87 percent even in the case of new vehicles that have suffered no degradation from exposure to road conditions.

Because new gasoline vehicles have made substantial headway in reducing gasoline-related nitrogen-oxide, out performing gasoline on this pollutant, with respect to such vehicles, is a difficult challenge. However, it appears that newly manufactured engines that are designed from the start for natural gas, whether this involves "dedicated use of natural gas" or "dual capability", can be engineered to prevent any nitrogen oxide problem before it begins.

In a study recently prepared for A.G.A.,[*] Professor E. J. Durbin of Princeton University concludes that an engine designed to run on natural gas could achieve reductions of nitrogen oxides by virtue of the leaner air/fuel mixtures that would be possible with such an engine. These emissions reductions could be achieved without the use of a catalytic convertor, thereby maintaining low emission levels that could not be maintained over time by a catalytic convertor. The efficiency of a catalytic convertor decreases rapidly with time as the catalyst becomes poisoned with exhaust products.

A list of Professor Durbin's key conclusions on fueling vehicles with natural gas is as follows:

1. This study has shown that from both emissions and efficiency points of view, gaseous fuels, and in particular natural gas fuels, are superior to gasoline in vehicular applications. The engine designer would prefer natural gas as a fuel over any other fuel.

2. Principal advantages of natural gas fuels come from the ability to more readily create homogeneous mixtures of air and fuel, which permits the use of lean combustible mixtures, and from the low carbon hydrogen ratio of fuel molecules.

3. Most assessments of emissions with natural gas fuels are based on fuel systems that have not been optimized for natural gas. These systems do not exploit the full advantages of natural gas fuels.

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[*] Durbin, E. J., Understanding Emissions Levels from Vehicle Engines Fueled with Gaseous Fuels; Princeton, N.J., Princeton University, February 1989.

4. In an engine "designed for natural gas" it should be possible to achieve oxides of nitrogen emissions much lower than those emissions from gasoline engines.

5. These low emissions should be attainable without catalytic convertors to clean up the engine exhaust.

6. Total hydrocarbons can be reduced 33 to 50 percent when using gaseous fuels. When the gaseous fuel is natural gas, environmentally active hydrocarbons can be reduced 90% as compared with gasoline.

7. With lean mixture control systems, carbon monoxide can be effectively eliminated from the exhaust of natural gas fueled engines.

8. Carbon dioxide emissions are reduced approximately one third as compared with gasoline.

9. An essential element in achieving these results, with good driveability, is a control system which adjusts air/fuel ratio to fit power requirements. Such a control system, coincidentally, provides increased fuel economy.

Of course, while newly manufactured NGVs can be expected to outperform retrofitted NGVs in emission levels and other respects, retrofitted NGVs are still the key to any immediate improvement in pollution from carbon monoxide and reactive hydrocarbons. NGV retrofitting is the only way that we can put large numbers of alternative-fuel vehicles on the road within the next few years.

After this discussion, it may be useful to summarize our emission reduction estimates in capsule form. Table I summarizes the emission reduction estimates for retrofitted vehicles.

TABLE I

A.G.A. AND NGV COALITION ESTIMATES OF ACHIEVABLE EMISSION REDUCTIONS PER VEHICLE WHEN GASOLINE VEHICLES ARE RETROFITTED TO NATURAL GAS*

Pollutant	Vehicles Using Older Gasoline Technology	Vehicles Using NEW Gasoline Technology
CARBON MONOXIDE	-99%	-82%
REACTIVE HYDROCARBONS	-92%	-87%

* Assumes use of proper procedures and equipment.

Use of Natural Gas in Heavy Duty Engines

Newly manufactured heavy duty trucks and buses must soon meet tightened EPA standards for heavy duty engines. Newly manufactured natural gas engines are an extremely attractive compliance option.

In 1988, newly manufactured natural gas buses, leased to the City of New York by Brooklyn Union Gas Company, were tested by EPA at the EPA facilities in Ann Arbor, Michigan. The results of these tests show that emissions from the buses met, or far surpassed, the EPA standards for model year 1991 gasoline-fueled heavy-duty engines.

For carbon monoxide, emissions were 10.6 grams per brake horsepower-hour (g/b-hp/hr), compared to a standard of 14.4.

For nitrogen oxide, emissions were 1.4 g/b-hp/hr, compared to a standard of 5.0.

For reactive hydrocarbons, which were only about 15% of the total hydrocarbons emitted, the bus emissions were extremely low. Even for total hydrocarbons, most of which do not appear to react chemically in the lower atmosphere, the bus emissions were 1.2 g/b-hp/hr. The standard is 1.3.

Greenhouse Effect Considerations

Given the rising interest in possible global warming consequences from an apparent Greenhouse Effect, any environmental policies should take into account the estimated direct and indirect carbon dioxide emissions from vehicular combustion of natural gas, gasoline, gas-derived methanol, coal-derived methanol and other fuels.

As this Subcommittee is well aware, carbon dioxide is thought to be the leading actor in the Greenhouse Effect.

With this concern in mind, we bring to your attention a recent Congressional Research Service Report for Congress entitled Carbon Dioxide Emissions From Methanol As A

Vehicular Fuel.

This Congressional Research Service report provides somewhat different numbers from those provided in an earlier World Resources Institute study. However, both studies agree on two key points: (1) use of coal-derived methanol in vehicles will substantially increase carbon dioxide emissions; and (2) direct combustion of natural gas in vehicles will substantially decrease such emissions.

The report estimates that, in comparison to gasoline, direct combustion of natural gas in vehicles will reduce carbon dioxide emissions by 30% or more.

Natural gas vehicles do emit some unburned methane. In fact, unburned methane accounts for most of the non-reactive hydrocarbons emitted by NGVs. As the term "non-reactive hydrocarbon" suggests, unburned methane is not a chemically interactive gas and does not contribute to smog formation. A.G.A. and the NGV Coalition are aware of speculation that unburned methane from natural gas vehicle tailpipes, while not chemically reactive in the lower atmosphere, may nevertheless pose environmental problems in the upper atmosphere because methane is a "Greenhouse gas". The Congressional Research Service has concluded that methane emissions from NGVs would be so miniscule that even if every vehicle in the world were to run on natural gas, the total additional emissions of methane would add only about 0.1% to the current methane emissions from all sources.* In fact, we believe, given our research on the issue, that NGVs reduce total vehicular greenhouse impacts by at least 25 percent even when considering methane emissions.

State Actions

In recognition of the air quality improvements that NGVs or other alternative fuel vehicles can make, states such as Texas, Arizona, and California have adopted measures to promote these vehicles. The most recent example of ambitious state action in this regard occurred in Texas, where the state legislature passed a bill on May 29, 1989 to promote NGVs and other clean vehicles.

The Texas legislation requires phased-in vehicle conversions to NGVs or other clean vehicles starting in 1991. State-owned or operated fleets with more than 15 vehicles, school districts with more than 50 buses, and local transit authorities must convert their fleets to NGVs starting in 1991 and finishing in 1998. The legislation anticipates private financing for the vehicle conversions but allows for waivers in instances where reasonable financing is unavailable.

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* Gushee, David E., "Alternative Fuels for Motor Vehicles, Some Environmental Issues," (Washington, D.C.: Congressional Research Service, 1988), pp. 17-18.

ECONOMIC BENEFITS OF NGVs

In addition to the obvious environmental benefits of natural gas, it may also be the most economical of all alternative fuels currently available. The cost of fueling a vehicle with natural gas is currently estimated to be about 30%-60% of the cost of fueling a vehicle with gasoline, including the additional cost of compressing the natural gas. The price per gallon equivalent of natural gas currently ranges from 40 to 75 cents. While the pump price of natural gas varies from region to region, much like gasoline, the typical sale price of natural gas averages approximately 62 cents per equivalent gallon. Furthermore, it should be pointed out that several gas companies, including A.G.A. and NGV Coalition member Pacific Gas and Electric Company, are developing a low pressure natural gas storage system which will significantly lower the overall cost of natural gas as a vehicle fuel by obviating the need for compression.

In addition to natural gas' lower pump price, and because of its clean burning qualities, natural gas offers significant savings in vehicle maintenance costs. Practical, on-road experience with natural gas vehicles shows that standard maintenance is half that of gasoline powered vehicles. Many users report that oil changes need not occur more than every 10-20,000 miles, and spark plugs, points and other components have lasted up to 75,000 miles in some vehicles.

SAFETY

Unlike many other alternative fuels currently under development, natural gas has a long and rich history as a vehicle fuel dating back to the infancy of the automobile itself. There are currently over 500,000 natural gas fueled vehicles worldwide, including over 30,000 in the United States. The lesson we have learned from this long history and extensive use is that natural gas may be the safest vehicle fuel of any type currently available, including gasoline.

A recent A.G.A. survey of natural gas vehicle fleet operators revealed that in over 434.1 million miles driven by the sample fleet, injury rates per vehicle mile traveled were 84% less than the national average for injuries per vehicle mile traveled for all U.S. registered vehicles.

In addition, the unique properties of natural gas itself make it extremely safe for use as a vehicle fuel. Unlike other alternative fuels, natural gas is neither corrosive nor toxic. Natural gas is lighter than air. Therefore, in the unlikely event of a leak, natural gas will safely dissipate into the air. Gasoline, and some other liquid alternative fuels, form dangerous puddles and pools on the ground in the event of a leak. Moreover, natural gas' ignition point is two times higher than that of gasoline, only igniting at a temperature of between 1200 to 1300 degrees, and only within a very narrow gas-to-oxygen mixture range of 5 to 15 percent.

Finally, the fuel tank cylinders for natural gas vehicles may be the safest and most extensively tested vehicle fuel storage system available. They are typically made of reinforced aluminum or three-quarter-inch-thick steel and have been subjected to severe abuse testing. Natural gas cylinders have successfully withstood blasting with dynamite, freezing, bonfires, and bullets, all without bursting or causing fire. None of the other alternative fuels, with the exception of, perhaps, propane, can make this claim.

NATIONAL SECURITY BENEFITS OF NGVs

America's reliance on imported oil is on the rise again. At this point, foreign sources meet more than 40% of the oil we consume every year -- and many of these foreign supplies come from OPEC countries. The need for transportation fuel plays a key role in our nation's inability to break free.

Since the internal combustion engine was invented, oil has held a virtual monopoly in the transportation fuels market. In every other major energy use market -- from chemicals to powerplants -- substitutes for oil are readily available and can be mobilized for use in the event of another disruption of imported oil supplies. In transportation, however, oil still reigns supreme.

To grasp the extent and implications of this oil dominance, consider the fact that transportation absorbs two-thirds of all the oil we use in America. If tomorrow we stopped using oil for everything else -- for heating homes, for making chemicals, for generating power -- we would still have to import oil just to feed our transportation sector.

Clearly, America will not be able fully to end its vulnerability to imported oil disruptions until America introduces competition in the transportation fuel markets.

Natural gas also has the benefit of a delivery system of over one million miles of existing pipeline. Through this pipeline network, natural gas can be brought to virtually any part of the nation for vehicular transportation.

AVAILABILITY OF NGV TECHNOLOGY

There may be some concern about the availability or reliability of current natural gas vehicle technology. But as I have previously stated, there is a long and rich history of the use of natural gas as a vehicle fuel. Of the

500,000 natural gas vehicles operating worldwide, Italy has almost 300,000 such vehicles on the road today. Other countries, such as Canada, New Zealand, and China have extensive experience with natural gas as a vehicle fuel and large operating fleets of such vehicles. The Soviet Union has recently announced its plan to convert one million of its vehicles to clean burning natural gas. In the U.S., we currently have approximately 30,000 natural gas vehicles on the road and operating today. These vehicles range from heavy duty buses, trucks, and delivery vans to personal family cars. While there is currently a high degree of reliability and safety associated with natural gas vehicle technology, the natural gas vehicle industry is continuing to develop and improve its equipment.

For example, the Ford Motor Company built 27 Ford Ranger pickup trucks which were designed and built from the ground up to run on natural gas. GSM Taxi, an NGV Coalition member company, is currently producing a line of long-life vehicles suitable for use as taxis or work vans that are designed to run exclusively on natural gas. Brooklyn Union has already purchased 12 of these vehicles for use as service vans in its fleet. Brooklyn Union is presently testing them on the streets of Brooklyn to assess their potential for use in the New York City market as service vans or as long-life taxis, something that New York, or many other cities for that matter, could desperately use.

For general vehicle use, there is currently a highly developed state of the art engine technology for light duty applications on vehicles weighing less than 8,000 pounds. Conversion kits are the most common applications for both carbureted and fuel injection engines. The various kits now on the market allow the conversion of existing engines either to run exclusively on natural gas or to be dual fuel capable, which allows the driver to run on either natural gas or gasoline.

The conversion kits for carbureted engines can be installed on any gasoline engine currently on the market. Conversion kits for fuel injected engines are also available and in fact, because of the more efficient mixing of fuel and air, fuel injection conversions are preferable.

There is also an extensive amount of work being performed in the design and development of engines dedicated to run exclusively on natural gas. Ford and GSM both have installed dedicated natural gas engines in their natural gas vehicles. Dedicated engines have also been built for NGV Coalition members to install in their company fleet vehicles.

There is also an extensive amount of work being performed in the development of heavy duty engine technology for vehicles weighing more than 8,000 pounds. Retrofit kits for diesel engines are available that allow diesel engines to run on a mixture of approximately 80% diesel and 20% natural gas. This mixture virtually eliminates the heavy particulate emissions produced by heavy duty diesel engines, as well as substantially reducing other harmful emissions. Southwest Gas Corporation has assisted the City of Phoenix, Arizona in retrofitting one of its transit buses with such a kit, and that bus is currently in operation in that city.

Diesel engines dedicated to running exclusively on natural gas are also currently under development. The NGV Coalition believes that such dedicated diesel engines will be the accepted standard for heavy duty engines in the near future as they will allow heavy duty diesel engines to meet the EPA's upcoming diesel emission standards. The Gas Research Institute has allocated a total of $11 million through 1992 to developing this and other natural gas vehicle technology. Cummins Engine Company has joined forces with the Gas Research Institute to develop a low emission heavy duty natural gas engine and has delivered the first of these engines. Also, Hercules Engine, an NGV Coalition member company, has announced its plan to deliver a dedicated natural gas diesel engine to market this year. Southwest Research Institute is developing a conversion kit which will allow existing diesel engines to be converted to run on natural gas.

The successful potential of heavy duty natural gas engine technology is being tested in Los Angeles. The Los Angeles Transportation Commission has a program which will involve the purchase of ten transit buses dedicated to running exclusively on natural gas. The program also involves the conversion of two diesel buses to run on a mixture of diesel and natural gas. Southwest Research Institute is performing the conversion with funding from Southern California Gas Company.

Brooklyn Union Gas Company is currently testing two natural gas buses in daily service in New York City. The buses were manufactured by Bus Industries of America using GM 454 engines that were converted to run exclusively on natural gas. As noted previously, the buses have been through extensive emission testing by the EPA at its testing lab in Ann Arbor, Michigan and have achieved excellent results. Furthermore, last summer Brooklyn Union drove one of its natural gas buses from New York City to the World Gas Conference in Washington, D.C. and back without any difficulty or problems. That trip was roughly the equivalent of a one-way drive from Los Angeles to San Francisco. In his address to the Conference, President Reagan praised our efforts in developing a clean-burning natural gas-fueled bus for use in New York City.

GAS SUPPLY AVAILABILITY FOR NGVs

There are clear environmental reasons to expand vehicular use of natural gas. There are no supply-related reasons to hold back.

We acknowledge that there may be infrequent, localized difficulties with gas deliverability. However, any such difficulties should be easily remedied because they are the result of either regulatory practices or operational logistics. So long as the domestic natural gas resource base remains free of price controls and other artificial market constraints, the domestic resource base -- particularly when it is coupled with supplemental North American gas sources in Canada and Mexico -- is large enough to meet substantially higher levels of gas demand. The resource base is also large enough to overcome the results of occasional marketplace misjudgments.

Recent Estimates of the Natural Gas Resource Base

A.G.A. does not stand alone in pointing to a large domestic natural gas resource base. The same conclusion has been reached by the Department of Energy (DOE).

In March of 1987, in a volume entitled Energy Security: A Report to the President of the United States, DOE told President Reagan:

> If unconventional gas supplies (such as gas shales, tight gas sands, and gas hydrates) are included in the

total, the Nation's supplies of natural gas may support 200 years of consumption at current rates.

In May of 1988, DOE issued a landmark study on natural gas supplies, entitled An Assessment of the Natural Gas Resource Base of the United States. In this May 1988 study, which drew upon the knowledge of a number of expert panelists, DOE focused solely on natural gas resources that are domestically available and can be recovered with today's technology. The study found that, in the lower 48 states alone, natural gas reserves and resources total 1,059 trillion cubic feet (Tcf). At the 1987 level of nationwide gas consumption, this amount is equivalent to a 62-year supply.

Of this 62-year supply of technologically recoverable gas, the equivalent of a 35-year supply is available at wellhead prices below $3.00 per million Btu's (MMBtu). This wellhead price range is not too different from prices that now occur at the peak of the winter heating season.

DOE adds that the 35-year supply can rise to a 45-year supply if wellhead prices rise to $5.00 per MMBtu. This range is far above today's prices, but still within the historical experience of gas consumers in the early 1980s. These supply figures do not include vast natural gas resources in Alaska (estimated by DOE at 129 Tcf), Canada and Mexico.

In short, DOE's estimates of the gas that is ultimately available to American consumers can be considered conservative. We add that DOE's resource base estimates are similar to the most recent estimates made by the Potential Gas Committee (PGC), a body of independent experts from throughout the natural gas industry. According to the latest PGC study, in the lower 48 states alone, conventionally recoverable gas at year-end 1988 (including "proven" reserves, which are already known to exist) was 832 Tcf. At 1987 gas consumption rates of roughly 17 Tcf per year, the PGC estimate is equivalent to a 49-year supply. Whether this Subcommittee prefers the DOE or the PGC supply estimates, it is clear that the lower 48 States are able to produce enough natural gas to meet expanded gas demand.

An "Elastic" Resource Base

In a December 16, 1988 letter that invited A.G.A. to testify at the field hearings of the Health and Environment Subcommittee of the House Energy and Commerce Committee, Chairman Waxman asked A.G.A. this question:

> In the context of both methanol and compressed natural gas, how much of the existing motor vehicle fleet in California and nationally could be powered for how long by currently known natural gas supplies?

This question highlighted the fact that the domestic supply of natural gas is an elastic resource base. A.G.A.

responded to the question by pointing out that, for a given number of vehicles, the volumes of natural gas required to fuel the vehicles indirectly -- through conversion of the natural gas to methanol -- will be more than 50 percent greater than the volumes required to fuel the vehicles directly. This is because more than one-third of the original energy content of natural gas is typically lost during the gas-to-methanol conversion process.

Beyond this response, it is important to note that a fixed natural gas inventory does not, in fact, exist. What exists instead is an "elastic" resource base: one that expands in response to the marketplace incentives of price level and demand level.

The lesson of an "elastic" resource base has become clear to the gas industry over the last 10 years. During the 1970s, prior to the enactment of the Natural Gas Policy Act of 1978, reserve replacements as a percentage of domestic production averaged 46 percent. During the 1980-88 period the reserve replacement ratio has averaged 89 percent. During the late 1970's and early 1980's, surging wellhead prices brought forth pioneering development of frontier gas resources -- including deep gas, tight sands gas and gas from deep waters offshore. Some frontier gas volumes became accessible as a direct result of the higher wellhead prices, while other volumes became accessible as a result of new technology induced by the higher wellhead prices. In any case, America's gas "inventory" was shown to be fluid instead of fixed.

In a variation on this theme, the subsequent drop in wellhead prices also expanded the scope of potentially accessible resources. Just as higher wellhead prices developed technology and expertise for reaching deep onshore and deep offshore gas, so lower wellhead prices induced more efficient drilling practices and development of lower-cost technology for tapping more gas from conventional onshore reservoirs. Once again, the resource base was shown to be "elastic".

Thus, we cannot say "how long" the nation's gas supplies will "last" if natural gas serves as a transportation fuel on a major scale. We can report, with recent history as our guide, that the domestic resource base will tend to grow as the nation's need to rely on it grows.

An Important New Study of Future Gas Supply and Demand

The Subcommittee may find it reassuring to know that a November 1988 report, prepared by two former high-ranking DOE officials, concludes that the nation could increase its natural gas consumption by a substantial amount without triggering any disruptive distortions of the energy marketplace.

The study in question, issued by Washington Policy and Analysis, is entitled Natural Gas: A Strategic Resource For the Future. The two authors are William Martin and Scott Campbell, both of whom served as high-level DOE officials in the Reagan Administration.

One major focus of the study is possible changes in overall gas supply and demand between 1987 and 2010.

Among other findings, the study concludes that, under an appropriate mix of low-cost public policy initiatives that are consciously designed to foster the increased use of natural gas, nationwide gas consumption could rise from the 1987 level of 17.1 Tcf to a new level of 24.1 Tcf in 2010. The study indicates that this major increase could occur without causing significant marketplace distortions, and the study explicitly addresses the question of how the necessary gas supplies can be obtained.

Apart from its substantive findings, the study is also historically significant for its methodology. The study is likely to represent a milestone in energy modeling because it provides the first independent analysis of the implications resulting from end-use technology developments and recent work in the area of gas resource base estimates.

POSSIBLE IMPACT OF NGVs ON OVERALL GAS DEMAND

We have attempted to develop, for the Subcommittee's information, some estimate of how large-scale use of NGVs might affect gas demand.

Our task has been complicated by the fact that America has placed on the road a great mix of vehicles, with a great diversity in fuel consumption patterns that reflects differences in engine type as well as major jumps in energy efficiency as we move from one "vehicle vintage" to another.

Table II indicates the diverse range of possible gas demand per vehicle, just among light duty vehicles.

TABLE II

ESTIMATED NATURAL GAS DEMAND PER VEHICLE PER YEAR*

In thousands of cubic feet (Mcf)

Type of Vehicle	Estimated Annual Gas Demand*
Old "Vintage" Passenger Car	100
Brand New Passenger Car	50
Average for All Passenger Cars, Old and New, On the Road in 1985	64**
Average for ALL LIGHT DUTY VEHICLES, Old and New, Including Light Duty Trucks, On the Road in 1985	76**

* Assumes exclusive use of natural gas.

** Derived from U.S. Department of Transportation data.

We estimate that if eight to ten million vehicles in the United States were converted to natural gas, they would only use approximately one trillion cubic feet of gas, or roughly six percent of our total annual consumption.

Since newly acquired buses must soon meet EPA's 1991 emission standards for heavy duty engines, the Subcommittee may be interested in an estimate of fuel consumption by natural gas buses. While we do not have a specific number for municipal buses, we do have a Department of Transportation number for fuel consumption by commercial buses in general, including intercity buses. Using this number as a starting point, we can offer a "ballpark" estimate that the average municipal bus, if using natural gas exclusively, would consume 860 Mcf per year.

While this consumption per vehicle is relatively high, the number of buses in America is relatively small. Almost 20,000 natural gas buses that use only natural gas would have to be placed in service before the increment of added gas consumption would reach one-tenth of 1% of the national gas consumption in 1987.

The attached and previously referenced study by two former DOE officials, Natural Gas: A Strategic Resource for the Future, provides a national perspective on possible gas demand for NGVs. The study speculates that, with low-cost but supportive public policies and vigorous efforts by the gas industry, natural gas could attain the following market shares by 2010:

-5% of the mass market for passenger vehicles

-25% of the market for public and private fleet vehicles (excluding military vehicles)

-75% of the market for commercial buses

These are reasonably ambitious market penetration goals for the natural gas industry. Yet the study concludes that, even if these goals were reached, gas demand for NGVs would be 1.7 Tcf per year, a very manageable amount of gas.

This is roughly 10% of the actual nationwide gas consumption in 1987.

COMPETITION BETWEEN NATURAL GAS AND OTHER ALTERNATIVE FUELS

Need For A Level Playing Field

We know the alternative transportation fuels market is not limited to natural gas and propane. Methanol, ethanol and electricity are also seeking shares of this market. Other energy sources, such as hydrogen, may enter this market in the future.

The gas industry would exclude no energy source from this market. We strongly favor the proverbial "level playing field": one which would permit all energy sources to compete on their own merits, restrained only by the needs of the customers and the public policy requirement that all of the competitors must meet acceptable standards for improving air quality.

Just as we would exclude no energy source from performance-oriented competition, so we would object vigorously and vocally to any effort to exclude natural gas from competing on its merits in this market.

Strong Points of Natural Gas

The natural gas industry is confident that its product will ultimately be a popular choice in the alternative transportation fuels market. There are strong reasons for this confidence.

First, for a wide range of pollutants, gas is the cleanest-burning transportation fuel. This fact carries great weight at a time when several dozen urban areas have failed to meet the Clean Air Act deadline for attaining ozone and carbon monoxide standards.

Second, as we noted earlier, gas supplies come mostly from the U.S.A. and almost exclusively from North America.

Third, as we have also noted earlier, natural gas has the advantage of high energy efficiency. This is a major reason for our clean-burning characteristics -- and for the low operating costs of our vehicles.

Fourth, while there are obviously many compressors and refueling stations to build, the gas industry already has in place a million-mile delivery system that brings natural gas to nearly every street corner in America.

Fifth, while newly manufactured vehicles would be most welcome, to put it mildly, the gas industry does not have to wait for Detroit since existing gasoline vehicles can be retrofitted to natural gas immediately.

HOW FEDERAL PUBLIC POLICY CAN HELP

Fleet Vehicle Use of Alternative Fuels

Meeting ozone and CO non-attainment standards can be accomplished via a flexible performance based approach for vehicles. For example, legislation could require that by a specified date a certain percentage of new vehicles in non-attainment areas must be clean vehicles and that the required performance standard could be that "clean vehicles" be 50% less polluting than EPA new car standards* (for the pollutant that causes an area to be in non-attainment).

A performance standard approach promotes flexible implementation. It would: allow localities to choose the fuel/technology which best meets their atmospheric condition; promote technological innovation to meet the standards in a more efficient and economic fashion; and provide incentives to all engine manufacturers and to all fuels -- including gasoline if technology advances.

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* The 50% figure is only a suggestion and another percentage may be more appropriate.

NGVs can generally outperform gasoline on operating costs but are impeded by capital costs that typically range from $1,000 to $2,000 for a retrofitted gasoline vehicle. For NGVs, and for all other alternative-fuel vehicles, to achieve significant market penetration, a performance based approach must be adopted.

Public and private fleet vehicles provide a manageable scope for the initiation of expanded use of clean vehicles. We urge Congress to enact meaningful federal legislation for the development of clean vehicles. Toward this end, the Alternative Motor Fuels Act of 1988 represents an important milestone. The authorization of funds for federal acquisition of alternatively-fueled passenger vehicles and light-duty trucks may provide the impetus for a network of refueling stations to be developed. The lack of nationwide refueling stations presents a significant barrier to expanded use of alternative-fuel vehicles. However, we point out that the commitment to alternative fuels must extend through the appropriations process.

Contemporary proposals that would also expand alternative-fuel vehicle use include S. 1058, introduced by Senator Jeff Bingaman, and its House counterpart, H.R. 2175, introduced by Representative Vic Fazio. These bills would require federal fleets in serious or severe health endangerment areas for ozone or carbon monoxide to become alternatively-fueled by increasing increments of 10 percent, beginning in 1993. A.G.A. and the NGV Coalition endorse these bills as measures that have great potential to break the impasse between an insufficient number of refueling stations to service additional vehicles and an insufficient number of vehicles to support a public refueling network.

Action to Establish An EPA Reactive Hydrocarbons Standard

The Environmental Protection Agency already has a total hydrocarbon standard in place to impose limits on hydrocarbon emissions. Traditionally, because NGVs were not considered numerous enough to have a significant impact on the environment, EPA has not been concerned with applying this standard to NGVs. Thus, EPA's total hydrocarbon standard has not posed a major impediment in the past.

As NGVs increase in number, EPA's total hydrocarbon standard could start to pose serious regulatory problems for many NGVs.

Natural gas vehicles emit very low levels of reactive hydrocarbons and typically encounter no difficulty in meeting a reactive hydrocarbon standard. At the same time, however, NGVs do emit some chemically inert gases (principally unburned methane). These chemically inactive emissions usually account for as much as 80-85% of the total hydrocarbon emissions from NGVs.

For this reason, a total hydrocarbon standard, which counts even those hydrocarbons that are chemically inert, poses a major problem for many NGVs.

The goal of hydrocarbon reduction is to improve ozone levels. Ozone is produced by a chemical reaction of hydrocarbons, nitrogen oxide and sunlight. Hydrocarbons are not a single chemical but rather a large family of chemicals that participate in ozone production reactions, to varying degrees. Some of these chemicals are highly reactive while others are virtually inert. The best possible regulatory program would weigh each hydrocarbon species according to its reactivity.

Given the monumental research effort that would be required to gain such reactivity information on each of the thousands of hydrocarbon species, the appropriate regulatory goal could be simplified by establishing only two categories of hydrocarbons: reactive and non-reactive. Under this regulatory scheme, all but the extremely photochemically inert compounds are considered reactive. This restructuring of the standard for hydrocarbon emissions would be a step forward in promoting cleaner-burning vehicles while protecting air quality from degradation.

To date, EPA has not been receptive to our informal requests for revision of this standard. However, Congressional action could rectify this problem.

Fortunately, EPA adoption of a reactive hydrocarbon standard was mandated in some of the leading air quality bills of 1988.

We urge Congress to include such a reactive hydrocarbon standard in any new air quality legislation.

Action to Adjust EPA Anti-Tampering Regulations

A similar problem is posed by standing EPA regulations that prohibit tampering with the emission control equipment on gasoline vehicles. If read narrowly, these established anti-tampering regulations can be construed to prohibit NGV retrofitting work on gasoline vehicles -- even though such retrofitting work will reduce vehicular emissions.

Like EPA's reactive hydrocarbon standard, the current anti-tampering regulations have not yet operated to impede any NGVs. However, the potential for EPA involvement is likely to rise as we see a dramatic increase in the number of NGVs on the road.

To date, EPA has not agreed to any gas industry requests for revision of, or favorable clarification of, the existing anti-tampering regulations. Fortunately, some of the leading air quality bills of 1988 included corrective language on this issue.

We urge Congress to include such corrective language, on EPA anti-tampering policies, in any new air quality legislation.

Adoption of Federal Tax Policies to Reduce Capital Cost Barriers to Acceptance of NGVs

Tax incentives can be very helpful in reducing the capital cost barriers to acceptance of NGVs and other alternative-fuel vehicles.

Tax policy falls beyond the jurisdiction of this Subcommittee. Nevertheless, because of the Subcommittee's strong interest in NGVs and other alternative-fuel vehicles, we note for the Subcommittee's information that Representative Mike Andrews (D-Texas) has introduced important tax policy legislation, H.R. 2269, on this subject.

H.R. 2269 was introduced on May 9, 1989. The purpose of the bill is to promote improved air quality through increased use of vehicles that use a clean-burning fuel. Toward that end, the bill would allow an "air quality" tax credit of 20 percent for business use of certain equipment. The credit is phased out beginning in the year 2000, with complete elimination of the credit by 2002.

Eligible equipment includes the following:

1. NGV conversion equipment installed in connection with a retrofit vehicle so that the vehicle is capable of running on natural gas.
2. The portion of the cost of a new, dedicated NGV that is attributable to the fuel storage, combustion, or exhaust.
3. The cost of NGV refueling stations. To promote NGV use by state and local governments, the bill would make credit-equivalent payments to these governments for the purchase of property that otherwise would give rise to the credit.

The bill applies to NGVs and to vehicles fueled by propane. It also applies to vehicles fueled by methanol or other alcohol fuels.

A.G.A. and the NGV Coalition endorse H.R. 2269 as an important reduction of the capital costs associated with expanding the use of alternative-fuel vehicles.

Utility Regulation Must Support the Sale of Alternative Fuels

Unfortunately, under current regulations, local gas distribution companies cannot sell natural gas to an independently-owned refueling station because of sale-for-resale restrictions. These restrictions need to be removed to facilitate the establishment of a needed refueling infrastructure.

Elimination of Regulatory Uncertainty

At present and for some years, standards applicable to the storage and transport of gasoline in vehicles and to emissions control equipment on gasoline engines have been established by both state and federal regulations. Similar standards for natural gas vehicles do not exist. To provide regulatory certainty and predictability to equipment manufacturers and suppliers, Congress should require the Department of Transportation to establish definitive compressed natural gas storage cylinder standards. In addition, uniform national testing standards must be established. The NGV Coalition is working with Sierra Research towards this end.

Federal Emission Standards for all Alternative Fuels Should be Established

Original equipment manufacturers must have standards against which to design and manufacture equipment. The high capital cost of such equipment prohibits manufacturers from investing in trial production runs. Certainty is needed. Unfortunately, with the exception of existing gasoline emission standards and the methanol standard recently promulgated by EPA, alternative fuels are in regulatory limbo. Appropriate standards and testing procedures are needed based on the unique attributes for each fuel. In the case of natural gas, a hydrocarbon standard that differentiates between reactive and non-reactive hydrocarbons is essential.

Federal Assistance for Research and Development Should be Expanded

A wide range of long-term research and development projects could facilitate commercialization of NGVs. A capsule description of these projects is listed below.

- Light Duty Engine R&D
    - Emissions testing of natural gas engines
    - Development of computer compatible natural gas engine systems
- Heavy Duty Engine R&D
    - Emissions testing of dedicated natural gas heavy duty engines
- Cylinders & Storage
    - Development of lightweight natural gas cylinders (any federal efforts should be coordinated with ongoing efforts of the Canadian Gas Association and the Gas Research Institute)
    - Metallurgic studies of gas effects on corrosion and stress cracking of cylinder materials (should be coordinated with the Canadian Gas Association and the Gas Research Institute)
    - Development of accoustic emission testing of cylinders, including in-place testing, without removal of cylinders from vehicles (should be coordinated with the Gas Research Institute)
    - Development of low pressure storage materials (adsorbents) and tank configurations
    - Development of standards for cylinders as on-board storage containers

- Refueling Station Technology
  - Development of novel, low-cost methods of high volume, fast fill fueling for transit buses
  - Development of inexpensive, advanced natural gas metering technology
- Catalyst Technology
  - Development of hydrocarbon and NOx catalytic converter specifically addressing lean-burn technology for light and heavy duty engines
- Vehicle Safety Standards
  - Analytical work and testing activity in support of the development of vehicle fuel system safety standards (e.g., crashworthiness, resistance to fire, and safe means of pressure release)
  - Analytical work and testing activity in support of standards for refueling facilities (e.g., indoor refueling, indoor storage of NGVs, and indoor location of compressors).

CONCLUSION

Natural gas vehicles can make a dramatic contribution to cleaner air. We have a technology that works, and we have the gas supplies to back up that technology.

There is no reason to restrain the expanded use of NGVs. There is every reason to encourage it.

We have spelled out, in some detail, specific ways in which Congress can remove the barriers to NGVs, and create low-cost incentives for their use.

We urge Congress to act on this information. The need for healthier air demands it.

Senator ROCKEFELLER. Thank you very much, Mr. Larson.
Dr. Roberts.

STATEMENT OF DR. GEORGE W. ROBERTS, GENERAL MANAGER, COMMERCIAL DEVELOPMENT DIVISION, AIR PRODUCTS AND CHEMICALS, INC.

Dr. ROBERTS. Mr. Chairman, my name is George Roberts. I am General Manager of the Commercial Development Division in the Process Systems Group of Air Products and Chemicals.

Air Products is currently involved in developing the liquid phase methanol process, a new technology for making methanol from coal, under the sponsorship of the Department of Energy and the Electric Power Research Institute. I am very glad to have the opportunity to testify today.

It is well-established that substituting methanol for conventional hydrocarbon fuels can produce significant environmental benefits in a wide number of combustion processes. These benefits can be obtained from mobile sources such as the ones we have been talking about today and also from stationary sources such as stationary gas turbine engines and boilers.

Mr. Philip Loring of the Environmental Protection Agency in his testimony on May 15, 1989, before the Subcommittee on Mineral Development and Production of this full committee, summarized the advantages of using methanol as an alternative fuel in some detail. I believe that that is the testimony that you were referring to earlier, Senator Rockefeller, and I won't try to repeat it.

Turning to stationary sources, methanol also produces very significant emission reductions in boilers and turbines. My detailed testimony sites tests that were run on stationary gas turbine engines and on stationary boilers. Those tests produced reductions in NO_X of up to 50 percent through conversion from conventional fuels, such as number 2 and natural gas to methanol.

Now, most methanol today is made from natural gas because the cost of production is lower than for any other feedstock. However, the technology for producing methanol from coal, an abundant, widely distributed, domestic resource, is improving very rapidly. Much of this improvement has been created by research programs sponsored by the DOE and by EPRI over the last decade. Air Products has been a cost-sharing sponsor and the prime contractor for one of these programs which has resulted in the development of the liquid phase methanol process.

The manufacture of methanol from domestic coal would have a major positive impact on the economy of the United States in a number of ways.

One problem is that dumping of methanol produced outside the United States from natural gas that is priced at artificially low levels has been a significant historical problem for U.S. producers of methanol. Periodic surpluses and shortages of offshore methanol have created very large swings in price and have been partly responsible for the shutdown of about 6,000 tons per day of domestic methanol capacity over the past 6 years.

My detailed testimony contains a graph showing that the price of methanol has swung between a low of 25 cents per gallon and a high of 60 cents per gallon over the last seven years. These swings do not encourage methanol production and utilization. The peaks discourage consumers and the valleys discourage producers.

The use of the liquid phase methanol process as part of a combined cycle coal gasification plant that co-produces methanol and electricity offers the possibility of a major reduction in the cost of making methanol from coal. At today's costs for coal and natural gas, the estimated cost of methanol from a co-product plant is about the same as the estimated cost of methanol from an all natural gas plant. This result represents a major success for DOE's fossil energy program.

Now, there are a number of Federal initiatives that would increase the penetration of methanol into the fuel market and reduce the time necessary to achieve the penetration. First of all, I think the Federal Government should significantly increase its support for programs aimed at demonstrating the usefulness of methanol in a variety of combustion applications and understanding infrastructure limitations associated with methanol. In this respect, my recommendation I think coincides with many other panelists today.

However, I think that these demonstration programs should place greater emphasis on two features: first of all, non-stationary applications because they are an important part of the overall fuel structure of the United States; and secondly, the demonstration of fuel grade methanol. Most of the methanol that has been used so far in demonstrations is highly purified chemical grade methanol. Fuel grade methanol is less purified, but available at a cost of perhaps 5 cents per gallon less than purified chemical grade methanol.

My second recommendation is that the Federal Government should encourage a stable market for domestically produced coal-based methanol. To obtain the full economic advantage from use of methanol as a fuel, Federal policy and legislation must favor domestic coal as a raw material and discourage dumping of methanol produced outside of the United States from artificially priced natural gas.

Initially the Federal Government could take steps to create stable markets for any methanol that is produced under DOE's clean coal technology programs. These are the production equivalent of many of the demonstration programs that have gone on. This stability would encourage coal to methanol projects under subsequent rounds of the clean coal technology program. Grants could be made to State and local governments to support the purchase of methanol produced in these clean coal demonstration plants at prices that would prevent foreign dumping of methanol from destroying the viability of these projects.

Another means to achieve the same goal is through tax incentives, and a simple, efficient mechanism would be to extend the non-conventional fuel tax credit to methanol that is actually produced in demonstration plants.

Senator **Rockefeller**. That is an interesting thought.

Dr. **Roberts**. That concludes my testimony. Thank you for the opportunity to address these issues, and I would be pleased to answer any questions.

[The prepared statement of Dr. Roberts follows:]

METHANOL AS AN ALTERNATIVE FUEL

TESTIMONY

of

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before the

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

June 8, 1989

Mr. Chairman and Members of the Subcommittee, my name is George W. Roberts. I am General Manager of the Commercial Development Division in the Process Systems Group of Air Products and Chemicals, Inc. Air Products is an international supplier of industrial gases, chemicals, process equipment and energy and environmental systems. The Company has annual revenues of about $2.5 billion and is headquartered in Allentown, PA.

I welcome this opportunity to testify before this Subcommittee on the subject of methanol as an alternative fuel.

Introduction

Methanol has many advantages as a fuel. Substituting methanol for conventional hydrocarbon fuels can produce major environmental benefits because of methanol's clean-burning characteristics and its freedom from trace contaminants. Methanol is useful in a wide range of combustion processes. With appropriate hardware modifications, it can partially or completely substitute for a variety of fuels such as natural gas, high-octane gasoline, diesel fuel and residual oil. Thus, the environmental benefits of methanol can be obtained in many combustion processes, not just in one or two niche markets. Moreover, methanol can be made from coal, a widely-available, domestic raw material. Therefore, expanded use of methanol can contribute to the solution of several pressing economic problems, such as regional unemployment and the balance of trade deficit, as well as contributing to the improvement of the nation's air quality.

Detractors of methanol point to several real or perceived disadvantages to its widespread deployment as an alternative fuel. These include: the higher cost of methanol relative to conventional fuels; the lack of infrastructure for the distribution and use of methanol fuel, and; methanol's contribution to the "greenhouse effect," especially in the case of coal-derived methanol. Congress and the Administration have an important and legitimate role to play in eliminating or minimizing these barriers to implementation and ensuring that the environmental and economic benefits of methanol utilization accrue to the public as quickly as possible.

Environmental Implications of Methanol Use

The outstanding environmental characteristics of methanol fuel are widely recognized and documented. In virtually all combustion applications, emissions of nitrogen oxides (NO_x) and sulfur oxides (SO_x) are reduced very significantly when methanol is substituted for a conventional, hydrocarbon fuel. These low-emission characteristics are intrinsic to methanol. The combustion temperature of methanol is quite low, so that thermal fixation of nitrogen, i.e., the production of NO_x by reaction of the nitrogen and oxygen in air, is very low. Moreover, the concentrations of sulfur and nitrogen in methanol are essentially nil; consequently, there is very little formation of SO_x and NO_x due to oxidation of sulfur and nitrogen compounds during the combustion process. Since NO_x and SO_x are the primary constituents of acid rain, methanol fuel is an attractive, albeit partial, solution to this well-publicized concern.

Emissions of carbon monoxide and reactive unburned hydrocarbons are also low when methanol is used as a fuel. This is a consequence of the ease of combustion of methanol and its decomposition products. Carbon monoxide, reactive unburned hydrocarbons and NO_x are ozone precursors, and ozone is the primary non-attainment air pollutant in many metropolitan areas nationwide, e.g., the front range of Colorado, Phoenix, Tucson, Southern California, New York City and Chicago.

The ability of methanol to substitute for a variety of conventional, petroleum-based fuels is truly remarkable. The conversion of automobile and truck engines, both gasoline and diesel, has received a great deal of well-deserved publicity and attention. Last month, students from fifteen universities in the United States and Canada participated in the 1989 Society of Automotive Engineers Methanol Marathon, a competition which required them to convert standard, gasoline-engine automobiles to operate on M-85, a blend of 85 percent methanol and 15 percent gasoline. These vehicles were then driven 1,100 miles, from Detroit to Washington, D.C. The rally tested fuel economy, cold starting, emissions and acceleration. Air Products and Chemicals, Inc. was one of the co-sponsors of this event and provided some of the methanol that was used for pre- and post-rally engine testing by the student teams. The methanol came from the Indirect Liquefaction Process Development Unit in LaPorte, Texas which is owned by the U.S. Department of Energy (DOE) and operated by Air Products. The methanol from LaPorte was "fuel-grade," i.e., it was taken directly from the methanol synthesis reactor without any subsequent purification.

This rally was an outstanding success! All fifteen cars finished. Average fuel economy was 32 miles/gallon on a gasoline-equivalent basis, which translates to 17.4 actual miles/gallon. The winning team averaged 36.7 mpg, again on a gasoline-equivalent basis. Emissions data have not been officially reported. However, preliminary results show that all fifteen cars met Federal standards for carbon monoxide and for unburned hydrocarbons. Some of the cars did not meet the NO_x standards, possibly because the students adapted the car engines to run at high compression ratios.

Previous studies on the pollution characteristics of automobiles that have been converted to run on methanol have shown that "tailpipe" emissions of formaldehyde, a carcinogen, are higher with methanol than with gasoline. This appears to be the only exception to methanol's outstanding environmental characteristics, and is probably unique to automobile engines because of the impact of cold starting on emissions.

Methanol is also being studied as a substitute for diesel fuel in trucks and buses, both in the U.S. and in Europe. This work is motivated, in part, by the need to reduce particulate emissions from diesel engines.

Stationary Applications of Methanol

Methanol can also substitute for conventional fuels in stationary applications. Methanol has been tested as a utility gas turbine fuel at least twice in the United States:

1) In 1974, a 12-hour test was conducted in a 26-megawatt gas turbine at the Bayboro Station of Florida Power Corporation.

2) In 1978 and 1979, the Electric Power Research Institute (EPRI) and Southern California Edison Company (SCE) sponsored a 520-hour test at SCE's Ellwood Energy Support Facility, using one half of a 52-megawatt, twin-engine, gas turbine generator unit. (1)

These tests showed that methanol can be successfully fired in a gas turbine, with minor system modifications.

In the Ellwood tests, nitrogen oxide emissions were less than half of those with either natural gas or distillate fuel, on a comparable basis. Sulfur oxide emissions were non-existent with methanol, and particulates were only about 30 % of the level with distillate fuels. The measured energy efficiency (heat rate) was about 1 % better with methanol than with distillate fuel or natural gas, due to the higher mass flow and lower combustion temperatures associated with methanol.

Methanol is also useful as a boiler fuel, substituting for natural gas, distillate oil or residual oil. Tests in a 35 MW utility boiler at SCE's Highgrove generating station (2) showed that NO_x emissions can be reduced by as much as 50 % by substituting methanol for either natural gas or low-sulfur oil. Moreover, staged combustion with 70 % natural gas (primary burners) and 30 % methanol (secondary burners) had about 50 % lower NO_x emissions than staged combustion with gas alone. Finally, staged combustion with 70 % oil/30 % methanol reduced NO_x levels by about 35 % compared to oil fired in a single-stage mode.

These stationary applications have received much less attention than the transportation applications. Data from field demonstration tests is not nearly as plentiful, especially data on fuel-grade methanol.

On balance, the combustion characteristics of methanol make it an outstanding candidate to replace a variety of petroleum fuels whose emissions characteristics are much worse than those of methanol.

Economic Issues Arising from Methanol Production and Use

Most methanol is made today from natural gas because the cost of production is lower than for any other feedstock. However, the technology for producing methanol from coal, an abundant, widely-distributed, domestic resource, has been improving very rapidly. Much of this improvement has been created by research programs sponsored by the DOE and EPRI over the last decade. Air Products has been a cost-sharing sponsor and the prime contractor for one of these programs, the results of which will be summarized later in this testimony. The manufacture of methanol from domestic coal would have a major, positive impact on the economy of the United States. It would make a significant contribution to the balance of trade deficit by offsetting the need to import crude oil, natural gas and refined petroleum products. A good deal of the crude oil that is currently imported into the United States originates in politically-unstable parts of the world, so that the development of a domestic methanol industry, producing methanol fuel from domestic coal, would contribute to long-term energy pricing stability and to energy and military security. Further, a methanol-from-coal industry would create significant amounts of domestic employment stemming from the operation of methanol plants, the mining of coal and the transportation of coal from mine mouth to plant gate.

"Dumping" of methanol produced outside the United States from natural gas that is priced at artificially-low levels has been a significant historical problem for U. S. producers of methanol. Periodic surpluses and shortages of off-shore methanol have created large swings in price and have been partly responsible for the shutdown of about 6000 tons per day (ca. 30 %) of domestic methanol capacity over the past six years. Figure 1 is a plot showing the contract price of methanol (FOB Gulf Coast) over the past seven years. Major, rapid price changes are a normal occurrence. These swings do not encourage methanol production and utilization. The price peaks discourage consumers from shifting to methanol from other fuels, and the valleys discourage producers from adding additional methanol capacity.

Rapid technology evolution is lowering the cost of producing methanol from coal. Over the last several decades, major advances have been made in three key elements of methanol manufacture: coal gasification, gas cleanup, and methanol synthesis. These advances have created two scenarios for the manufacture of methanol:

1. The so-called "all methanol" scenario, where coal is gasified, impurities are removed from the coal gas (synthesis gas) and its composition is adjusted chemically, and the coal gas is converted, essentially quantitatively, into methanol.

2. The so-called "coproduct" scenario, where methanol and electric power are coproduced in a coal gasification combined cycle (CGCC) plant. A schematic diagram of such a plant is shown in Figure 2.

The "coproduct" scenario, in conjunction with the Liquid-Phase Methanol Process (LPMEOH)* which is currently being developed under the sponsorship of the DOE and EPRI, may offer a major reduction in the cost of making methanol from coal. At today's costs for coal and natural gas, Figure 3 shows that the required selling price of methanol coproduced in a CGCC/LPMEOH plant is comparable to that of methanol produced from natural gas in a world-scale, "all-methanol" plant. For example, if coal costs $1.50/MM BTU, the required methanol selling price from a coproduct plant producing 414 MW and 870 tons/day of methanol is about $0.40/gal. For natural gas at $1.50/MM BTU, the required selling price for a 2000 T/D plant is about $0.50/gal. The advantage of $0.10/gal. that methanol from a coproduct (CGCC/LPMEOH) plant appears to enjoy in this example is not the result of a strict, controlled comparison of the two production scenarios. There are differences between the two cases in areas such as plant scale, methanol purity and financing assumptions which can affect the magnitude, and even the direction, of the difference. Nevertheless, the comparison does illustrate that the coproduction of methanol and power from coal has major economic potential, and offers a means to produce methanol from coal at required selling prices that are very close to those of methanol made from natural gas, even at today's low natural gas prices.

*LPMEOH is a trademark of Chem Systems, Inc.

Another important feature of the "coproduct" scenario with the LPMEOH Process is a major reduction of specific $C0_2$ emissions, i.e., pounds of $C0_2$ emitted per pound of methanol burned as fuel. For an "all-methanol" from coal plant, based on conventional technology for methanol synthesis, about 3.6 pounds of $C0_2$ are emitted per pound of methanol produced and burned. This figure is reduced to a net of about 2.9 pounds/pound with a "coproduct" plant based on the LPMEOH Process. For comparison, burning methanol from an "all-methanol" from natural gas plant produces about 1.8 pounds of $C0_2$ per pound of methanol produced and burned. These figures show that the "coproduct" (CGCC/LPMEOH) scenario eliminates about one-third of the excess $C0_2$ emissions associated with making methanol from coal instead of natural gas.

Figure 4 (3) shows that the coproduction of methanol and electric power has the potential to significantly reduce the cost of electric power produced by a CGCC plant, with the exact amount of cost reduction depending on the methanol selling price. For example, if methanol sold at $0.60/gallon and if a coproduct plant were sized to coproduce 414 MW of power and 665 tons/day of methanol, the required selling price of the power would be $0.038/Kilowatt-hr. (Kwh). This is about 10 % less than the required selling price of $0.042/Kwh. for a straight CGCC plant, with no methanol coproduction. This creates a very interesting environmental and economic synergism: the coproduction of methanol, the cleanest burning liquid fuel, can accelerate the commercialization of combined cycle power generation, the cleanest and most efficient means of generating electric power from coal.

For both economic and environmental reasons, these developments represent a major success for DOE's Fossil Energy program. To a large extent, this breakthrough has been created by the development of the Liquid-Phase Methanol Process, which was invented by Chem Systems, Inc. Beginning in 1981, consistent advances have been made in this technology for synthesizing methanol. During late 1988 and early 1989, a series of runs was made in the DOE's Indirect Liquefaction Process Development Unit at LaPorte, Texas. These tests demonstrated a number of important economic advances in the LPMEOH process:

1) A greatly-simplified reactor design, which lowers the required capital investment and improves operating reliability.

2) A greatly-reduced catalyst deactivation rate, which lowers the cost of catalyst replacement.

3) Operation with a very concentrated catalyst slurry, another significant contributor to reduced capital investment.

4) The use of continuous catalyst addition and withdrawal to maintain catalyst productivity, another contributor to reduced operating cost.

5) Very rapid response to changes in gas flow rate, a convincing demonstration of the suitability of the LPMEOH Process for load following in a CGCC plant, e.g., the coproduct scenario.

Demonstration and commercialization of the Liquid-Phase Methanol Process is being aggressively pursued. In response to DOE's solicitation for the Clean Coal Technology (I) program, the Tennessee Valley Authority (TVA) submitted a proposal to demonstrate the technology at a scale of about 40 tons of methanol per day at TVA's Muscle Shoals, Alabama site. By the time that the solicitation for the Clean Coal Technology (II) program issued, the LPMEOH Process had been developed more completely, and several areas of technical risk had been reduced. Therefore, Coolwater Gasification Associates submitted a proposal to demonstrate the technology at a scale of about 100 tons per day in conjunction with continued operation of the Coolwater CGCC plant. Neither of these proposals was approved by the DOE, perhaps fortunately, in view of the continued rapid rate of technology development. Air Products plans to submit another proposal under the Clean Coal Technology (III) solicitation. Ideally, the proposed project will be located at the site of an existing coal gasifier and will be sized to produce up to 500 tons per day of methanol. This is roughly the same size of unit that is required for a commercial-scale, 400 MW CGCC plant.

In addition to pursuing demonstration projects under the various Clean Coal programs, Air Products has actively sought privately-funded projects. Interest in the technology has been encouraging, but the perceived risk in scaling up from the 10 tons per day process development unit at LaPorte to a full-scale plant producing several hundred to several thousand tons per day of methanol is intimidating to potential investors. Nevertheless, Air Products is continuing its efforts to participate in a privately-funded demonstration or commercial project via the LPMEOH Process.

Recommendations

There are a number of Federal initiatives that would increase the penetration of methanol into the fuel market and reduce the time necessary to achieve this penetration:

1. The Federal government should significantly increase its support for programs aimed at demonstrating the usefulness of methanol in a variety of combustion applications and at understanding the technical and infrastructure problems that might inhibit the widespread utilization of methanol in these applications.

As noted earlier, a number of demonstration programs exist in transportation applications. These should be increased in number and size. Non-transportation (stationary) applications, such as steam boilers and stationary gas turbines, should receive much more attention and increased Federal support. All of these demonstration programs should emphasize the use of "fuel grade" methanol, preferably made from domestic coal. To date, almost all of the methanol that has been used in demonstration programs has been so-called "chemical-grade" methanol, which is highly purified at an extra cost of up to about 5 cents per gallon. In order to set the stage for an industry that produces methanol for fuel uses, it is critically important to demonstrate the use of "fuel-grade" methanol in a wide variety of applications as soon as possible.

Federal support for an expanded series of demonstration programs in a variety of applications would hasten a broad understanding of methanol's characteristics as a fuel and a recognition of the benefits (and problems) that accrue from the use of methanol. It would also lead to a clearer and earlier definition of infrastructure constraints. An expanded program of demonstration and testing would also create an initial market for fuel-grade methanol. This is a very important factor. In classical, "chicken-or-egg" fashion, the limited market for "fuel-grade" methanol that exists today discourages production and vice versa.

2. The Federal government should encourage a stable market for domestically-produced, coal-based methanol.

To obtain full economic advantage from widespread use of methanol as a fuel, Federal policy and legislation must favor domestic coal as a raw material for methanol production, and must discourage "dumping" of methanol produced outside the United States from natural gas that is priced at artificially low levels.

Initially, the Federal government should take steps to create stable markets for any methanol that is produced under DOE's Clean Coal Technology programs. This would encourage coal-to-methanol projects under subsequent rounds of the program.

Grants should be made to state and local governments to support the purchase of methanol produced in Clean Coal demonstration plants, at prices that free the project sponsors from the economic uncertainties associated with rapid swings in the "free market" price for methanol, as shown in Figure 1. Effectively, such grants would set a floor price for methanol produced from coal in these demonstration programs, and would prevent foreign dumping of methanol from destroying the viability of these projects. These grants would also accelerate the methanol utilization programs referred to earlier.

Another means to achieve these same goals is through tax incentives for methanol-from-coal demonstration projects. A simple and efficient mechanism would be to extend the non-conventional fuel tax credit to methanol actually produced in these demonstration plants. Alternatively, a tax credit based on investment in methanol-producing facilities could be considered. Tax incentives have been applied at both the State and Federal levels to stimulate the use of ethanol as a fuel. Extension of similar credits to methanol produced from domestic coal would help to level the playing field of alternative fuels.

The same problem of price stability will persist as methanol-from-coal projects move into a fully commercial phase. Through a combination of tax and procurement policy, the Federal government can prevent artificially-priced foreign methanol from destroying a fledgling U.S. methanol-from-coal industry as it develops.

3. The Federal government should support creative research on control of emissions from automobile engines fueled with M-85 and neat methanol (M-100).

As noted earlier, the one possible disadvantage of methanol fuel is its tendency to form formaldehyde during the cold start of automobile engines. This problem might be attacked by formulating automotive emission catalysts that are tailored to methanol's combustion properties, e.g., to rapidly oxidize formaldehyde at relatively low temperatures. Research aimed at the development of such catalysts should be accelerated through Federal support.

4. The Federal government should increase its support of research on the "greenhouse" effect.

The "greenhouse effect" is widely used as an argument against encouraging the increased utilization of methanol fuel, especially methanol made from coal. However, there is a great deal that is not known about the "greenhouse effect," and the inevitability of global warming due to increased carbon dioxide concentrations in the earth's atmosphere is not universally accepted (4). Better climatological models appear to be needed to support a rationale, worldwide policy on carbon dioxide emissions. In the meanwhile, Federal policy should not preclude or delay the environmental and economic benefits associated with methanol utilization.

References:

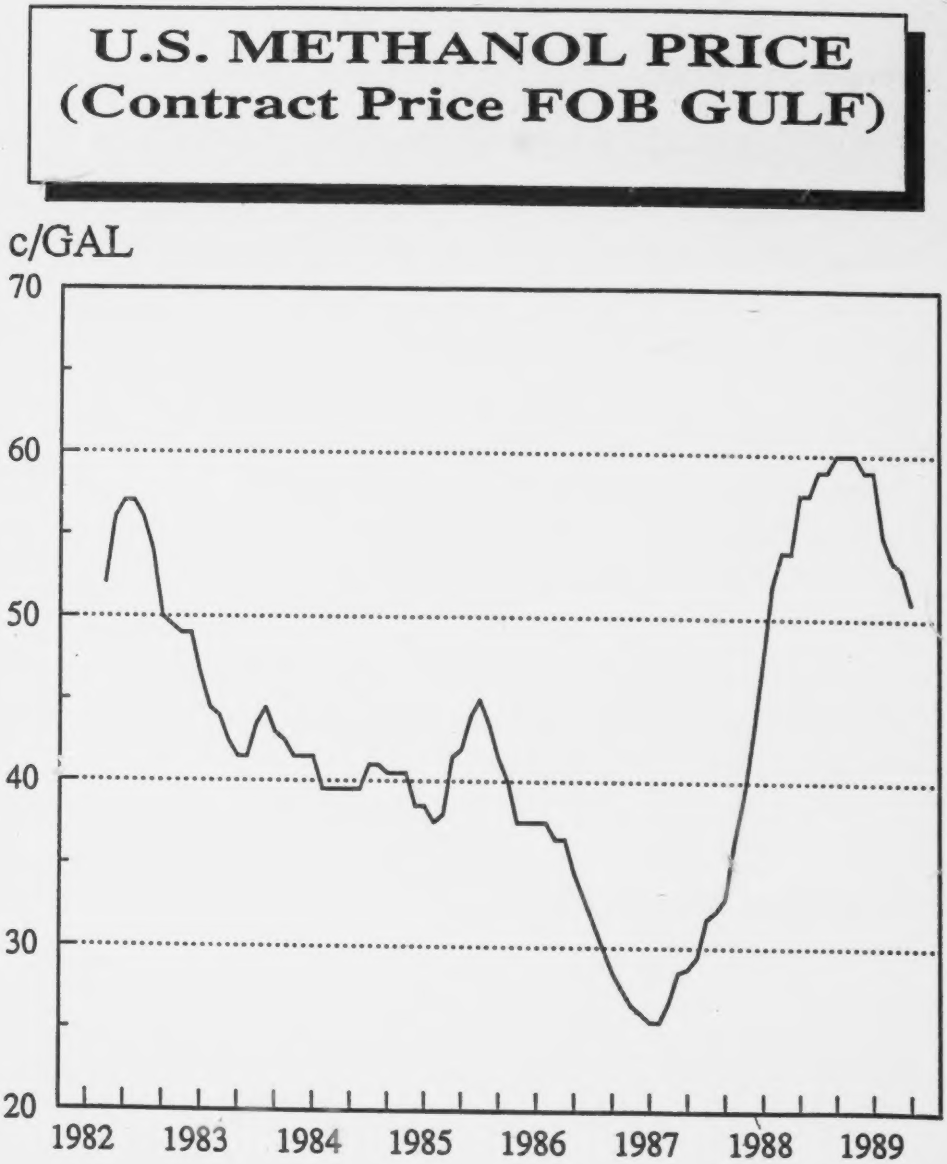
(1) "Test and Evaluation of Methanol in a Gas Turbine System," Electric Power Research Institute (EPRI) Report AP-1712, Research Project 988-1, February, 1981

(2) "Dual Fuel Methanol Combustion," 1987 Symposium on Stationary Combustion Nitrogen Oxide Control- Volume 2, EPRI Report CS-5361, Volume 2 p. 46-1, August, 1987

(3) "Coproduction of Electricity and Methanol," W. R. Brown, R. B. Moore and J. Klosek, Eighth EPRI Coal Coal Gasification Contractors' Conference, Palo Alto, CA, October 19-20, 1988

(4) "Carbon Dioxide: A Contrarian Point of View," S. B. Idso, Alternate Fuels Industry Annual Meeting, Tucson, AZ, April 17, 1989

FIGURE 1



U.S. METHANOL PRICE (Contract Price FOB GULF)

Source: TECNON's Methanol Newsletter

MeOHPRICE 5/25/89

FIGURE 2

COPRODUCTION POWER AND METHANOL VIA IGCC

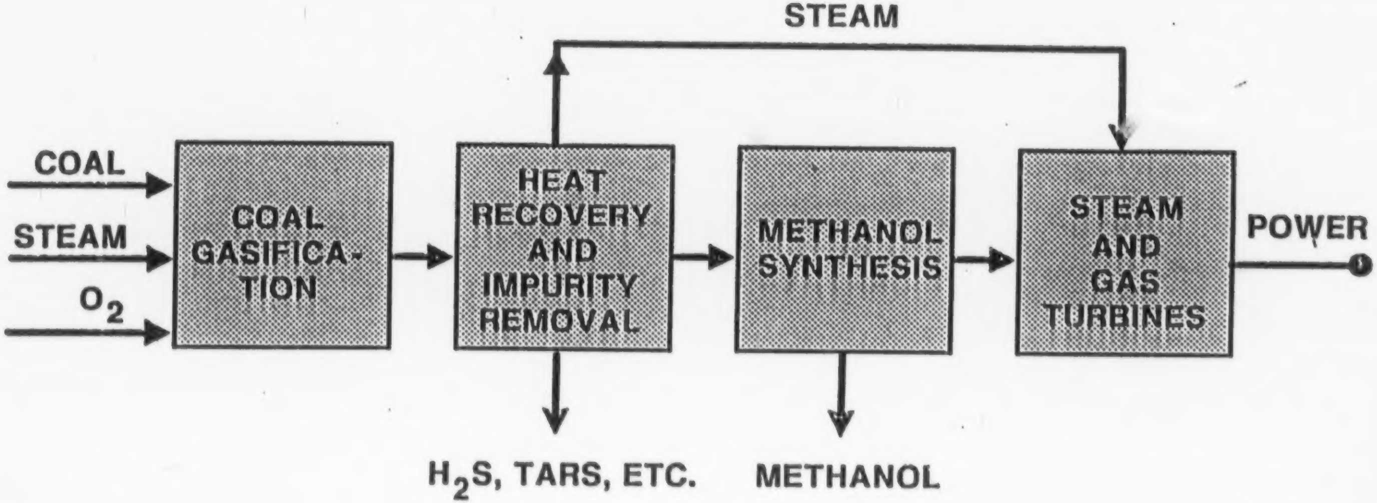

STEAM
COAL
STEAM
O_2
COAL GASIFICATION
HEAT RECOVERY AND IMPURITY REMOVAL
METHANOL SYNTHESIS
STEAM AND GAS TURBINES
POWER
H_2S, TARS, ETC.
METHANOL

FIGURE 3

COST OF METHANOL

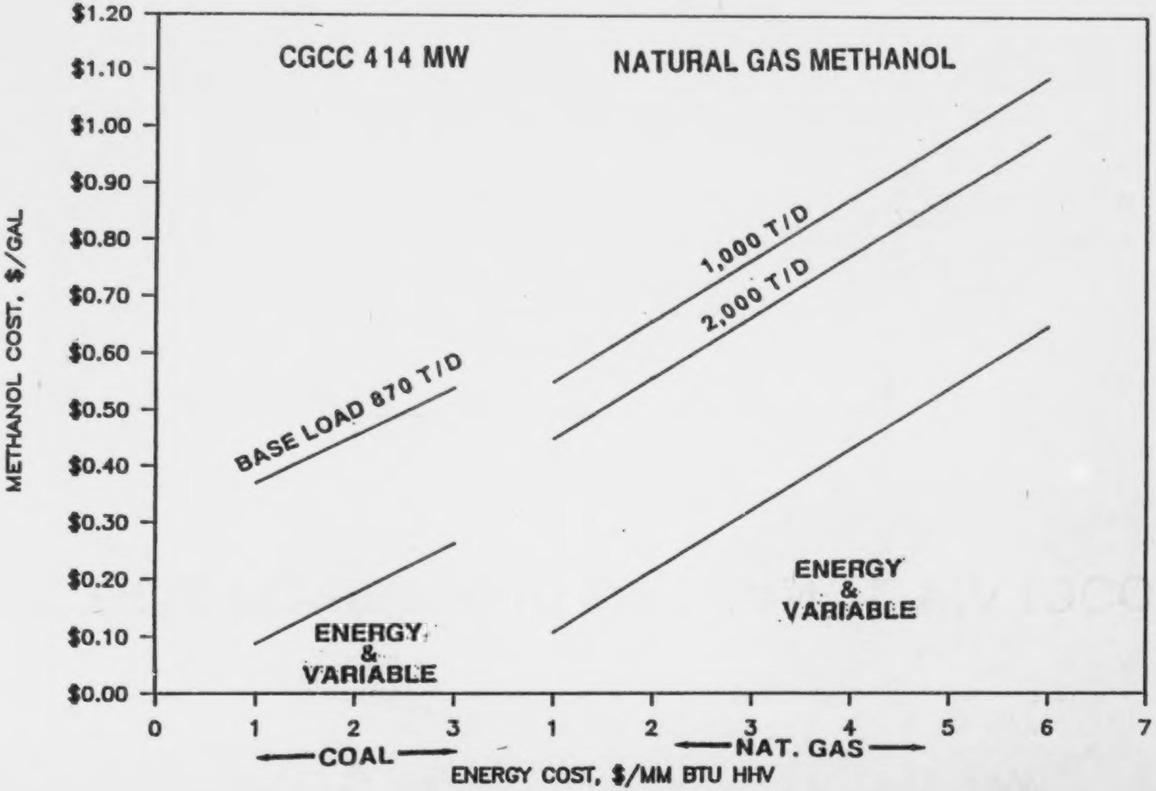
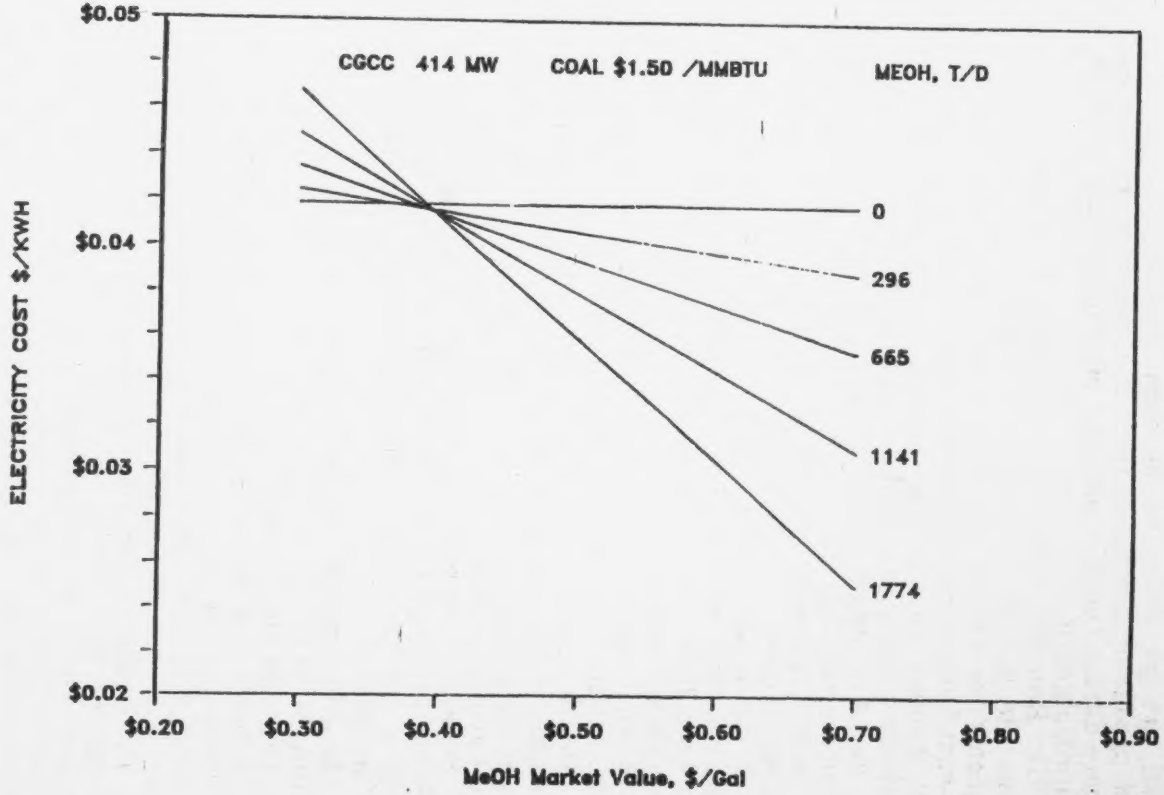


FIGURE 4
ELECTRICITY COST VS. METHANOL PRICE



Senator **Rockefeller**. Why, Dr. Roberts, you admirable individual, are you so bullish on clean coal technology and its possibility of producing methanol from coal when everybody has sat around here during the day and kind of written it off? You are doing something about it.

Dr. **Roberts**. Well, there is not a simple answer to that question, but the fact of the matter is I have been involved in these programs for almost a decade. There is a lot of my own blood and sweat behind trying to make them successful. And through that involvement, I think I have come to appreciate the advantages and where it can apply. And I would like to see it happen.

Senator **Rockefeller**. Listening to both of you, I wish that you had started this off. I think it might have brought a little bit more realism to everybody else or at least put some more pressure on them to come up with honest answers.

I would say this to both of you. You are in the business of making this work. And you have to make it work because you have to be able to prove to your board of directors that this is something which is continued.

Now, how much are you depending upon clean coal technology financially for what you are doing, or are you not in fact?

Dr. **Roberts**. In the short term, the demonstration of this new methanol technology probably depends heavily on the DOE's clean coal technology programs. In the long term, the technology is going to have to be able to stand alone on its own feet.

Senator **Rockefeller**. And that is a lot of money. What is it? Seven hundred fifty million dollars that is annual I think in the clean coal technology program. Senator Byrd makes sure of that. [Laughter.]

In other words, you just reacted to it and you are doing something with it.

Dr. **Roberts**. Trying.

Senator **Rockefeller**. Trying to. What gave you this glimmer? You could have gone off in other directions too taking something other than coal. Why did you decide to go in this direction and make it work with coal?

Dr. **Roberts**. Our involvement in this particular area dates back from the late 1970's and early 1980's when we had a burst of national energy associated with using our domestic coal resources. We feel we had perhaps a better opportunity than some of the other things that were going on at that time. And with the continuing sponsorship of the Department of Energy and the Electric Power Research Institute, we stuck to it.

Senator **Rockefeller**. When do you think realistically that making methanol from coal will be—and in this I do not know how one factors in economies of scale and all the rest of that—competitive, for example, with making it from natural gas?

Dr. **Roberts**. I have to give you a two-part answer to that question. There are two ways to make methanol from coal. One way is the co-product scenario that I have referred to, and that is co-producing methanol and electric power as part of a large power generation station such as cool water. I believe that that could be competitive economically as quickly as the technology could be scaled up. And that is one of the reasons that I have placed emphasis on the clean coal technology programs because I think those programs give us the earliest possible opportunity to scale the technology up.

Senator **Rockefeller**. What kind of time are you talking about?

Dr. **Roberts**. Several years, 3 or 4 years.

Senator **Rockefeller**. So, you would not exactly agree with Chevron that the year 2050, if we are lucky, is the magic year.

Dr. **Roberts**. I think that Chevron in their testimony has perhaps looked more at the second scenario for making methanol from coal, and that is what we call the all-methanol scenario where you did not co-produce power. That is a less economic scenario than the co-production scenario, and although I certainly could not validate their 2050 date, I would say that it is going to be a longer time frame before particular scenario is economically competitive with natural gas.

Senator **Rockefeller**. How much money do you use from the clean coal technology program? And in what ways can Government be helpful to you in your pursuit?

Dr. **Roberts**. Well, we have not been awarded a grant or a contract under the clean coal technology program. We will be submitting a proposal under Clean Coal III. The details of the proposal haven't been worked out, so I would be on rough ground to try to give you a number. But it would probably be on the order of $50 million.

Senator **Rockefeller**. And help me on this. Just take me through a little bit, to the extent that you can, what you will be doing with that should you win that $50 million.

Dr. **Roberts**. What we would do is—we are currently running a 10-ton per day pilot plant to demonstrate this liquid phase methanol process. Our intent would be to build a 500-ton per day methanol plant that used synthesis gas made from coal. Our intent would be to try to locate that plant at the site of an existing coal gasifier so that we would not need to build a whole new gasifier to demonstrate the methanol technology.

Senator **Rockefeller**. Mr. Larson, there are, as you have indicated, many impressive benefits from natural gas vehicles. There are some questions that have been raised about them, a couple at least I would like to go over with you.

Is there anything that can be done about the limited driving range problem of natural gas vehicles?

Mr. **Larson**. Yes. There is a study, research project, under way now to use an adsorbent in the storage tanks whereby we expect that we will probably be able to double the capacity for the same size tanks.

Senator **Rockefeller**. Is that something which is being worked on currently?

Mr. **Larson**. It is being worked on currently.

Senator **Rockefeller**. Is it complicated?

Mr. **Larson**. It is not complicated.

Senator **Rockefeller**. The adsorbent doesn't sound very complicated.

Mr. **Larson**. No, it is not.

Senator **Rockefeller**. So, when do you think that the doubling——

Mr. **Larson**. It is a known technology. I think by the end of the year we will have some kind of an answer on that project.

Senator **Rockefeller**. It perhaps could double the range.

Mr. **Larson**. It does one of two things depending on what our objectives want to be. And that is, it can increase the capacity of the present storage, or it could reduce the pressure for the same capacity. And the attraction for that is that reduces the compression costs for the compressor that is used to fuel the vehicle. So, there are tradeoffs there.

Senator **Rockefeller**. Yes, but it is a very exciting statement.

Mr. **Larson**. Absolutely. It has been under way now for six months or so.

Senator **Rockefeller**. Well, you just answered that extremely well.

The Department of Energy appears to estimate infrastructure costs for natural gas vehicles—I'm a little more skeptical about DOE after this hearing——

[Laughter.]

Senator **Rockefeller** [continuing]. At over 50 percent more than for methanol to displace a million barrels a day of oil.

Let me say that again to make it clear. DOE appears to estimate infrastructure costs for natural gas vehicles at over 50 percent more than for methanol to displace a million barrels a day of oil. Without original manufacture of natural gas vehicles, there is added cost of conversion. California officials have said emissions data for natural gas vehicles are to this point lacking. But I gather that for natural gas buses, problems remain with NO_x emissions. Could you comment on some of these problems?

Mr. **Larson**. Let me start with the first, the DOE estimate. I have not seen that. I do not know where it comes from. I would really need to look at that to find out how they arrived at that.

Senator **Rockefeller**. But you could respond to it.

Mr. **Larson**. And we would respond if you could make that available.

Senator **Rockefeller**. We will.

Mr. **Larson**. The next one was?

Senator **Rockefeller**. The added cost of conversions.

Mr. **Larson**. Yes. True, there is an added cost of conversion initially, and that is a cost that applies to—if you want to convert a lot of vehicles right now, you have to go through that additional cost.

However, we feel the long-term route to go is to go the dedicated vehicle, and we have a project under way. In fact, we have a small manufacturer. The large manufacturing companies, because of the expense of tooling up or retooling, will not become players until we are talking something like 100,000 or 200,000 vehicles a year.

However, we are in touch with a small vehicle manufacturer who is manufacturing and will be delivering—we have ordered 12 in Brooklyn Union Gas—dedicated vehicles. It is a taxicab service type of vehicle which is using all General Motors parts, General Motors engine, General Motors drive train, dedicated to natural gas. His plans are to make 1,000 in 1990, 10,000 in 1991. The name of the company is the GSM Company.

Senator **Rockefeller**. Final question. Do public service commissions allow you to include the cost of natural gas vehicles and fueling equipment in the rate base?

Mr. **Larson**. As of now, they have not. We have that issue under discussion with them.

Senator **Rockefeller**. If they did, would that give natural gas as an alternative fuel a competitive advantage?

Mr. **Larson**. Not necessarily. I don't think the commissions would allow us to put it in rate base and charge it. If that particular market did not support that cost, they would not allow us to have it subsidized by other customers. And we don't think it would have to be subsidized other customers either.

Senator **Rockefeller**. I want to thank both of you because you are the people who are making it work. Again, I wish I had spent the time on you that I had on the first panel because basically what you are both saying in your testimony and what you are, in fact, doing is bringing methanol, natural gas vehicles on stream through your own work.

Dr. Roberts, you are doing this without a dime to this point. You would like to get $50 million and you may or may not, but in any event, you are working on it which shows an attitude which is certainly not necessarily in sync with what I heard from the Department of Energy.

Dr. **Roberts**. Perhaps a correction. Air Products has spent a good deal of its own money on it, but we have also had support from the Department of Energy and the Electric Power Research Institute.

Senator **Rockefeller**. I am glad of that then.

Mr. **Larson**. There was one other question you asked, and that was relative to the NO_X on buses that I didn't answer.

Senator **Rockefeller**. Yes. I'm sorry.

Mr. **Larson**. Our two buses are meeting the 1991 standards. That is on NO_X, CO and the full range.

Senator **Rockefeller**. It is very clear that we have a lot of directions in which we can go, isn't it? There are a lot of alternative fuel possibilities out there. And yet, as I say, in 1987 we burned 128 billion gallons of gasoline. We have lessons to learn and things to do, don't we?

Mr. **Larson**. Yes, we do.

Senator **Rockefeller**. I thank you, gentlemen, very much.

The record for this hearing will remain open for 10 days for various written statements and answers to questions.

I particularly appreciate the patience of both of you gentlemen. This hearing is adjourned.

[Whereupon, at 5:55 p.m., the hearing was adjourned.]

APPENDIX

ADDITIONAL STATEMENTS SUBMITTED FOR THE RECORD

Garry Mauro
Commissioner
General Land Office

Testimony of the Honorable Garry Mauro
Texas Land Commissioner

Regarding Alternative Fuels for Transportation

Before the Energy Research and Development Subcommittee
of the Senate Energy and Natural Resources Committee

United States Senate

June 6, 1989

Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701
(512) 463-5256

Mr. Chairman, members, I am very pleased to submit testimony in support of alternative fuel use for vehicular transportation.

Back home in Austin, our state legislature has just passed a package of clean air proposals unlike anything you are used to seeing from a "pro-business" state like Texas. It is a package drafted by my staff and me at the Texas General Land Office and has the active support of a 32-member coalition of industry, labor, consumer and environmental groups brought together for the first time as the "Clean Air Texas" coalition.

A number of additional industry groups, individual companies and chambers of commerce have concurred in supporting the legislation beyond those who have joined the coalition. These are strange bedfellows, ladies and gentlemen. Right there in Texas we have the Audubon Society, the Sierra Club and the American Lung Association joined together in active support of the same legislative package as major oil and gas companies, independent oil and gas producers, and gas pipeline and distribution companies, not to mention the League of Women Voters, the Texas Consumer Association and Public Citizen.

Our legislative package has principal sponsors in the Texas House and Senate from both political parties and a bi-partisan list of 57 co-authors in the House from both ends of the political spectrum. We have received the editorial endorsement of fifteen major newspapers from every region of the state. A list of Clean Air Texas members, editorial endorsements and co-authors is attached to my testimony for your record.

This broad range of support has come together in the same "pro-business" political climate that we have always had and will continue to have in Texas. The difference now is that our business community, our major news media and a majority of our elected officials have come to recognize that clean air must be part of a strong business climate; they see cleaning up the air as promoting future economic development, rejecting the old misconception that clean air simply adds to the cost of doing business.

Members, our constituents have been telling us for a long time that they do not want to breathe air that they can see, smell and taste. They do not want to ingest toxic substances by simply breathing the air, to contribute to the further degradation of our forests through acid rain or the further warming of our planet through "greenhouse gases".

Passage of these bills is evidence of the broad-based political will throughout my state for action to clean up the air. With creative law-making and an effort at coalition building instead of the old single-interest politics, we can enact clean air legislation this year not only at the state level but at the federal level as well. That will give our citizens what they want and deserve--a quality of life that ensures cleaner air without undue economic sanctions or sacrifices.

Let me tell you how we propose to begin that process in Texas.

Our legislation mandates all transit authorities, state agencies with more than 15 vehicles, and school districts with more than 50 school buses to convert their fleets to clean-burning alternative fuels according to a phased schedule beginning in 1991 when these entities will be prohibited from purchasing new vehicles that are not capable of using alternative fuels. The next phase is a three-tiered schedule which mandates percentages of the total fleet to be capable of using clean-burning alternative fuels: 30 percent by 1994; 50 percent by 1996; and 90 percent by 1998. In nonattainment areas that still require additional control measures in 1996, local governments with more than 15 vehicles and private fleets with more than 25 vehicles would also be mandated to convert, again according to a phased-in schedule that will result in 90-percent alternative-fuel use in those fleets by 2002. As a matter of practicality, law enforcement and emergency vehicles are exempted from the mandate. And recognizing that one alternative fuel may show greater benefits over another in certain areas, our legislation is fuel-neutral. It allows a fuel choice and gives the Texas Air Control Board the authority to recommend which alternative fuel would be most effective in reducing harmful air pollutants in particular areas.

There are several unique elements of our alternative-fuels legislation which made it more widely acceptable and which we believe can and should be incorporated at the federal level. First, and most importantly, we ensured that it was revenue-neutral to the affected entities by devising a first-of-its-kind, "free market mandate".

Put simply, alternative fuel suppliers are encouraged to provide conversion kits, fueling stations and other infrastructure without up-front capital expenditures on the part of the users by offering or arranging long-term financing to be paid back through the cost-savings realized from purchasing alternative fuels that are cheaper than gasoline or diesel fuel. While the fuel savings, which average 30 to 60 percent when compressed natural gas (CNG) replaces gasoline or diesel, are used to pay back finance charges, maintenance cost reductions of as much as 50 percent begin accruing from the beginning of the conversions. If such revenue-neutral financing cannot be arranged to reasonably ensure that conversion costs will not exceed what would otherwise be paid for conventional fuels, then a waiver from the mandate can be obtained.

Another waiver is provided if there is no central fueling station available for the alternative fuel and one cannot reasonably be expected to be established. We also explicitly allow "after-market" conversions to count toward the fleet percentage requirements of the bill, again leaving it up to the free market to determine if the major auto manufacturers and dealers wish to get involved in supplying original equipment manufacturer alternative-fueled vehicles. If they do not wish to respond in the short-run, there is no reason to delay the conversion provisions, because the after-market converters are able to respond.

Furthermore, the technology for operating vehicles on CNG is available and continues to develop at a rapid pace. Soon two-cycle diesel engines can be retrofitted to operate on 100 percent CNG. Since

90 percent of the transit buses on the road are powered by two-cycle engines, the ability to retrofit these engines is critical towards achieving the desired environmental impact to the urban environment.

Let me pause a moment and address the special problem presented by diesel exhaust emissions in our urban environments. Diesel particulates are one of the greatest contributors to the "brown clouds" in our cities. Every one of us has been behind a dirty diesel bus on the road or at a stoplight when the emission stream was almost too much to bear.

I am presenting an exhibit to the subcommittee which was provided to us by laboratory scientists at Southwest Research Institute in San Antonio, Texas. This clear bottle contains just five minutes worth of particulate emissions from a typical diesel engine. When you shake the bottle, you see that what looks like a couple of inches of black soot is actually very fine particles which hang in the air and circulate for a remarkable amount of time.

We must control these particulates if we are going to reverse the brown cloud phenomenon. I am not talking about the PM_{10} standard and whether or not our urban areas are in attainment for particulates. I am talking about controlling harmful diesel emissions at the tailpipe because cleaner fuels are available right now. We must ensure that EPA does not relax the 1991 standard for diesel emissions from transit buses or the 1994 standards for all heavy-duty diesel vehicles. We must also ensure that these standards are seen simply as a beginning from which further diesel emission reductions will be achieved, not as an end in themselves.

Again, let me repeat that many of our major business groups in Texas have either endorsed or concurred in this legislation. In Texas, ladies and gentlemen, we have just enacted mandates for fleet vehicle conversions to alternative fuels, as well as other clean air provisions which promote new technologies to reduce emissions at new or existing utility and industrial plants and impose a surcharge for burning a dirty fuel when cleaner alternatives are available during six months of the year. Instead of trying to define away a problem through statutory maneuvers while our air quality continues to worsen, we have taken concrete actions which complement the current regulatory structure.

My interest for promoting alternative fuels like compressed natural gas and propane is straightforward. As Texas Land Commissioner, I am a statewide elected official who manages over 21 million acres of oil and gas producing lands which, along with the rest of the production in Texas, account for more than one-fourth of the proven gas reserves in this country. I can speak to this knowledgeable committee from a producing state perspective and pledge that adequate gas supplies are deliverable throughout this nation at reasonable prices for at least another 60 years. I also represent a producing state coalition that is ready to join in a national effort to clean up our air through meaningful legislation enacted this year.

And that leads to my second and most important reason for providing this testimony to you today. My staff and I, like you, have spent the last several years grappling with the seemingly intractable problem of cleaning up our urban air. We have achieved what I outlined to you today at the state level by forming new coalitions and agreeing upon new approaches that avoid some of the old, very narrow statutory debates.

More than 8 million Texans today breathe air known to be unhealthy. Those most at risk are our children and our elderly and that is intolerable. Three reports in the last six months have cited Texas as one of the worst sources of air pollution in the nation. Burning Texas natural gas in our own state will encourage economic development and help reverse these trends.

Burning more natural gas nationwide will have the same positive effects because it is cost-effective to consumers, addresses the full range of air pollution problems (from urban smog to global warming) simultaneously, and utilizes a domestic fuel consistent with our energy security objectives.

Mr. Chairman, members, my staff and I would be happy to work with your staffs and with any others crafting any version of alternative fuels legislation to ensure that these principles of promoting natural gas and clean air through an alliance of common national interests are achieved.

I hope this testimony adds something concrete and worthwhile to your proceedings.

CLEAN AIR TEXAS COALITION

Honorable Garry Mauro, Commissioner of the Texas General Land Office and President of Clean Air Texas, D-Austin
Honorable John Sharp, Texas Railroad Commissioner, D-Austin
Texas State Senator Kent Caperton, D-Bryan
Texas State Senator Don Henderson, R-Houston
Texas State Representative Hugo Berlanga, D-Corpus Christi
Texas State Representative David Cain, D-Dallas
American Lung Association
Amoco
Audubon Society
Clean Water Action Project
Thomas D. Coffman, Inc.
Jack Dutton
East Texas Producers and Royalty Owners Association
Entex
Fuller Company
Houston Pipeline
Intercon Gas
League of Women Voters
Lone Star Gas Co.
Ronald Martin, Inc.
Mitchell Energy
Mobil Natural Gas, Inc.
Public Citizen
Rally Pipeline Corporation
Sierra Club
Southern Union Gas
Texas Conservation Foundation
Texas Consumer Association
Texas Environmental Coalition
Texas L. P. Gas Association
TIPRO
Gene Wright, Inc.

NATURAL GAS AND CLEAN AIR EDITORIALS

Bryan-College Station Eagle	April 28, 1989
Austin American-Statesman	April 17, 1989
Beaumont Enterprise	March 16, 1989
Corpus Christi Caller-Times	April 27, 1989
Dallas Morning News	February 26, 1989
Dallas Times Herald	February 20, 1989
El Paso Times	March 22, 1989
Houston Post	February 23, 1989
Longview News Journal	March 26, 1989
Lufkin Daily News	March 12, 1989
Orange Leader	March 22, 1989
San Antonio Express-News	February 28, 1989
San Antonio Light	March 7, 1989
Sulphur Springs News-Telegraph	May 5, 1989
Tyler Morning Telegraph	March 14, 1989
Waco Tribune-Herald	March 6, 1989

HOUSE CO-AUTHORS OF TEXAS CLEAN AIR LEGISLATION

Rep. Erwin Barton, D-Pasadena
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Rep. Weldon Betts, D-Houston
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STATEMENT BEFORE THE
SENATE ENERGY RESEARCH AND DEVELOPMENT SUBCOMMITTEE
RELATING TO
THE STATUS OF CURRENT AND FUTURE USE OF ALTERNATIVE FUELS

2:00 PM
366 DIRKSEN BUILDING
WASHINGTON, D.C.

SUBMITTED BY:

LEONARD W. LEVINE
COMMISSIONER,
MINNESOTA DEPARTMENT OF TRANSPORTATION
JUNE 6, 1989

MR. CHAIRMAN, I AM LEONARD LEVINE, COMMISSIONER OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION. THANK YOU, MR. CHAIRMAN, FOR PERMITTING ME TO APPEAR BEFORE YOUR SUBCOMMITTEE. I AM VERY PLEASED TO BE HERE. THE SUBJECT OF ALTERNATIVE FUELS IS ONE THAT HAS FAR-REACHING IMPORTANCE TO OUR NATION.

IF WE CONTINUE TO RELY EXCLUSIVELY ON PRESENT FUELS AND TECHNOLOGY WE FACE VERY SERIOUS CONSEQUENCES. FIRST, WE FACE THE VERY REAL POSSIBILITY OF ONCE AGAIN BEING HELD AN ENERGY HOSTAGE BY FOREIGN POWERS. I AM SURE WE ALL REMEMBER WELL WHAT THAT CAN MEAN TO OUR INDIVIDUAL LIFESTYLES AND TO THE NATIONAL ECONOMY. THEN THERE IS ALSO THE MORE IMMEDIATE PROBLEM OF AIR QUALITY. PRESENT FUELS AND TRANSPORTATION TECHNOLOGY HAVE CONTRIBUTED TO A SERIOUS THREAT TO THE PUBLIC HEALTH IN MANY OF THE NATION'S URBAN AREAS. WHILE CONTINUED RELIANCE ON EXISTING FUELS AND TECHNOLOGY POSE SERIOUS THREATS TO THE NATIONAL HEALTH AND SECURITY, THERE IS ALSO REASON FOR OPTIMISM.

WE ARE STANDING ON THE LEADING EDGE OF A NEW ERA IN ENERGY RESEARCH AND TECHNOLOGY. THE ACTIONS THAT YOU AND OTHERS TAKE REGARDING ENERGY ALTERNATIVES WILL HAVE FAR-REACHING CONSEQUENCES ON TRANSPORTATION, THE ENVIRONMENT AND ENERGY CONSERVATION.

AS TRANSPORTATION COMMISSIONER, I AM VERY AWARE OF THE FACT THAT THE PERSONAL AUTOMOBILE CONTINUES TO BE THE MODE OF TRANSPORTATION PREFERRED BY THE VAST MAJORITY OF AMERICANS. IN

1987, AMERICANS TRAVELED NEARLY TWO TRILLION MILES IN THEIR CARS AND TRUCKS. VEHICLE TRAVEL IS CONTINUING TO GROW. IN FACT, AT PRESENT RATES, TRAVEL IN MANY OF OUR URBAN AREAS WILL DOUBLE IN THE NEXT 15-20 YEARS.

AUTOMOBILE TRAVEL AND OUR TRANSPORTATION INFRASTRUCTURE HAVE SHAPED OUR CITIES, EXPANDED MARKET AREAS AND ENRICHED CHOICES ABOUT HOW WE SPEND OUR LEISURE TIME. THEY HAVE ALLOWED MANY OF US TO TRAVEL LONG DISTANCES TO JOBS AND BUSINESSES. THEY HAVE ALSO ALLOWED DISTANT PLACES LIKE MINNESOTA TO SUCCESSFULLY COMPETE IN NATIONAL AND INTERNATIONAL MARKETS.

YET THE COSTS OF EVER-INCREASING VEHICLE TRAVEL ARE BECOMING PAINFULLY EVIDENT. THESE COSTS ARE REFLECTED IN OUR INCREASING ENERGY DEPENDENCE AND IN THE WORSENING ENVIRONMENTAL PROBLEMS WE FACE. I BELIEVE THAT THE FEDERAL GOVERNMENT, THE STATE GOVERNMENT AND THE PRIVATE SECTOR EACH CAN MAKE IMPORTANT CONTRIBUTIONS TO HELP SOLVE THE TWIN ENERGY AND ENVIRONMENTAL PROBLEMS THIS NATION FACES.

I WOULD LIKE, MR. CHAIRMAN, TO FIRST OF ALL DISCUSS THE STATE ROLE. I WILL USE MY OWN STATE OF MINNESOTA AS AN EXAMPLE OF THE KIND OF EFFORTS THAT I BELIEVE CAN MAKE REAL CONTRIBUTIONS TOWARD SOLVING THESE PROBLEMS.

IN MINNESOTA, WE ARE FORTUNATE. WE ARE NOT YET EXPERIENCING THE SEVERE AIR QUALITY PROBLEMS OF CITIES LIKE LOS ANGELES, DENVER AND PHOENIX. NEVERTHELESS THE STATE IS TAKING STRONG AND CONCERTED ACTION TO PROTECT AND ENHANCE THE ENVIRONMENT.

GOVERNOR PERPICH HAS TAKEN A LEADERSHIP ROLE AMONG STATE GOVERNORS IN WORKING TOWARD AN "ENVIRONMENTAL COMPACT OF THE STATES". SUCH AN INTERSTATE COMPACT WOULD DEAL WITH ENVIRONMENTAL ISSUES THAT EXTEND BEYOND THE BORDERS OF ANY ONE STATE, SUCH AS ACID RAIN, WATER POLLUTION AND AIR POLLUTION. STATE SUPPORT FOR THE PROPOSAL WAS VERY EVIDENT DURING THE LAST SESSION OF THE MINNESOTA LEGISLATURE, WITH THE APPROPRIATION OF $100,000 TO SUPPORT THE GOVERNOR'S EFFORTS.

THE MINNESOTA DEPARTMENT OF PUBLIC SERVICE HAS BEEN ASSIGNED AGENCY RESPONSIBILITY TO DEVELOP A STATE ENERGY POLICY. THE AGENCY I REPRESENT STRONGLY SUPPORTS THE DRAFT STATE ENERGY POLICY. THE POLICY INCLUDES SUCH TRANSPORTATION-RELATED OBJECTIVES AS INCREASED FUEL EFFICIENCY, NEW ROADWAY DESIGNS TO ENCOURAGE RIDESHARING, SUPPORT FOR MASS TRANSIT AND EXPANSION OF BICYCLE/PEDESTRIAN OPTIONS.

THE UNIVERSITY OF MINNESOTA, CENTER FOR TRANSPORTATION STUDIES, HAS ANNOUNCED SEVERAL AREAS FOR RESEARCH EMPHASIS IN 1989-90. THE CENTER HAS REQUESTED PROPOSALS FOR RESEARCH ON INNOVATIONS THAT LINK VEHICLE TECHNOLOGY TO INFRASTRUCTURE DESIGN AND

MANAGEMENT. THIS INCLUDES METHODS TO EVALUATE POLLUTION AND ENERGY IMPACTS THAT RESULT FROM TRANSPORTATION.

AS A MEMBER OF THE STATE ENVIRONMENTAL QUALITY BOARD I ASSIST IN ENFORCING STATE ENVIRONMENTAL QUALITY STANDARDS AND REVIEWING AND APPROVING STATE ENVIRONMENTAL IMPACT STATEMENTS. I MIGHT ADD THAT MINNESOTA'S EIS APPROVAL STANDARDS ARE CONSIDERABLY MORE STRINGENT THAN THE FEDERAL GOVERNMENT'S. IN MINNESOTA, EIS APPROVAL REQUIRES THAT THE ENVIRONMENTALLY LEAST DAMAGING FEASIBLE ALTERNATIVE BE CHOSEN FOR PROJECT IMPLEMENTATION.

AS CHAIRMAN OF THE GOVERNOR'S SUBCABINET ON ENERGY, ENVIRONMENT AND RESOURCES I AM RESPONSIBLE FOR COORDINATING THE RELATED ENERGY AND ENVIRONMENTAL PROGRAMS OF 10 STATE AGENCIES. THESE PROGRAMS WILL OBTAIN ADDITIONAL FUNDING FROM A NEWLY CREATED ENVIRONMENTAL TRUST FUND. CREATION OF THE TRUST FUND INVOLVED PASSAGE OF A STATE CONSTITUTIONAL AMENDMENT, A STRONG INDICATION OF THE PUBLIC SUPPORT FOR ENVIRONMENTAL PROGRAMS IN MINNESOTA.

FINALLY, MR. CHAIRMAN, I WOULD LIKE TO ANNOUNCE THAT I AM ESTABLISHING ALTERNATIVE FUELS AND INNOVATIVE TRANSPORTATION TECHNOLOGIES AS A HIGH PRIORITY WITHIN THE MINNESOTA DEPARTMENT OF TRANSPORTATION. IN ORDER TO INSURE THAT THE RELATED FUNCTIONS ARE CARRIED OUT EFFECTIVELY, THEY WILL BE ASSIGNED AS A PRINCIPAL RESPONSIBILITY FOR ONE OF THE DIVISIONS WITHIN THE DEPARTMENT. THE DIVISION WILL BE RESPONSIBLE FOR PROVIDING A FOCUS FOR A

PARTNERSHIP WITH INDUSTRY AND OTHER UNITS OF GOVERNMENT AND WILL ALSO BE GIVEN THE RELATED FEDERAL LIAISON RESPONSIBILITIES.

NEXT, I WOULD LIKE TO DISCUSS THE ROLES OF THE FEDERAL GOVERNMENT AND THE PRIVATE SECTOR, AS I SEE THEM. I WILL DISCUSS THESE TOGETHER BECAUSE I BELIEVE THEY MUST BE CLOSELY COORDINATED AND INTERCONNECTED.

BOTH THE PUBLIC AND THE PRIVATE SECTORS HAVE IMPORTANT ROLES TO PLAY IN THE SEARCH FOR ALTERNATIVE FUELS AND INNOVATIVE TRANSPORTATION TECHNOLOGIES. THE PRIVATE SECTOR IS CAPABLE OF RESPONDING TO IMMEDIATE NEEDS IN A VERY EFFICIENT MANNER. THE OIL CRISIS OF THE 1970'S HAS SHOWN US THAT MARKET FORCES ARE BEST ABLE TO ALLOCATE AVAILABLE FUEL SUPPLIES EFFICIENTLY. THE PRIVATE SECTOR, HOWEVER, IS LESS ABLE TO ALLOCATE RESOURCES FOR LONG RANGE NEEDS NOT ADEQUATELY REFLECTED IN TODAY'S MARKET. WITHOUT GOVERNMENTAL INVOLVEMENT, WE CANNOT REALISTICALLY EXPECT PRIVATE COMPANIES TO DO THE RESEARCH AND DEVELOPMENT WORK NEEDED TODAY TO BRING ALTERNATIVE FUELS AND OTHER ADVANCED TRANSPORTATION TECHNOLOGY ON LINE TO MEET TOMORROW'S NEEDS.

HERE IS WHERE I SEE A VERY IMPORTANT ROLE FOR GOVERNMENT, ESPECIALLY AT THE FEDERAL LEVEL. ADDITIONAL RESEARCH AND A FOCUSED DEVELOPMENT EFFORT IS NEEDED TO EVALUATE THE STRENGTHS AND WEAKNESSES OF ALTERNATIVE FUELS AND OTHER ADVANCED TRANSPORTATION TECHNOLOGIES. SUCH TECHNOLOGIES MUST BE EVALUATED

IN TERMS OF THEIR COSTS, THEIR IMPACT ON AIR QUALITY, THEIR FEASIBILITY FOR VEHICLE USE AND OTHER FACTORS. IN THE ABSENCE OF SOME STIMULUS FROM GOVERNMENT, OR A CRISIS SITUATION WHERE MARKET FORCES SUDDENLY BEGIN TO PROVIDE THE ECONOMIC INCENTIVES NECESSARY, THE PRIVATE SECTOR CANNOT BE EXPECTED TO PURSUE SUCH LONG RANGE RESEARCH AND DEVELOPMENT.

THUS FAR THE FEDERAL EFFORT HAS FOCUSED ON NECESSARY RESEARCH INTO ALTERNATIVE FUELS. IT IS NOW TIME FOR AN EXPANDED FEDERAL DEMONSTRATION PROGRAM TO COMPLIMENT THE RESEARCH EFFORT. THE MOTOR FUELS ACT PASSED BY CONGRESS LAST YEAR IS A STEP IN THE RIGHT DIRECTION. IT ENVISIONS FEDERALLY SPONSORED DEMONSTRATION FLEETS, NUMBERING PERHAPS 5000 VEHICLES OF ALL TYPES, FUELED BY A VARIETY OF ALTERNATIVE FUELS. IT IS THROUGH THIS TYPE OF FOCUSED DEVELOPMENT EFFORT THAT THE FEASIBILITY OF ALTERNATIVELY FUELED VEHICLES CAN BE DEMONSTRATED, AND WIDESPREAD USE IN THE PRIVATE SECTOR ENCOURAGED.

TODAY'S AIR QUALITY PROBLEMS IN MAJOR URBAN AREAS PRESENT AN OPPORTUNITY TO ENCOURAGE PRIVATE SECTOR ACTION. THE DEVELOPMENT AND IMPLEMENTATION OF ALTERNATIVE FUELS OR OTHER ADVANCED TRANSPORTATION TECHNOLOGY IS LIKELY TO PLAY A MAJOR ROLE IN IMPROVING AIR QUALITY. ALREADY, THE PRIVATE SECTOR IS BEGINNING TO "GET THE MESSAGE" THAT SOMETHING MUST BE DONE.

THE THREAT OF STRICTER ENVIRONMENTAL CONTROLS PLAYED A MAJOR ROLE IN FORD'S DEMONSTRATION OF AN ELECTRIC VAN AND A "FLEXIBLE FUEL" CAR, EQUIPPED TO RUN ON ETHANOL, METHANOL OR GASOLINE, HERE IN WASHINGTON RECENTLY. GENERAL MOTORS, IN TURN, SPONSORED A DETROIT-TO-WASHINGTON ROAD RALLY INVOLVING 200 CHEVROLET CARS EQUIPPED TO RUN ON METHANOL. THE POINT I WANT TO MAKE IS THAT THE PRIVATE SECTOR IS ABLE TO RESPOND IN A FAST AND EFFICIENT MANNER WHEN THE INCENTIVES TO DO SO ARE THERE.

UNTIL ALTERNATIVE FUELS AND NEW TECHNOLOGIES COME ON LINE, WE MUST LOOK AT SHORT TERM STRATEGIES TO MINIMIZE IMPACTS. AS COMMISSIONER OF A TRANSPORTATION DEPARTMENT, I AM MOST CONCERNED WITH TRANSPORTATION SERVICE AND SAFETY. THE PRIORITY CONCERN OF MANY OF THE SPEAKERS YOU HAVE HEARD TODAY IS AIR QUALITY. THE COMMON FACTOR TO BOTH TRANSPORTATION SERVICE AND AIR QUALITY IS DEMAND MANAGEMENT. BY DOING A BETTER JOB OF MANAGING THE DEMAND ON OUR NATION'S HIGHWAYS WE CAN REDUCE AIR QUALITY IMPACTS, CONSERVE GASOLINE, MINIMIZE CONGESTION, IMPROVE SERVICE AND ENHANCE SAFETY. IN MINNESOTA, I HAVE CREATED AN OFFICE WITHIN MY DEPARTMENT WHOSE MISSION IT IS TO IMPLEMENT WAYS TO MANAGE THE DEMAND FOR TRANSPORTATION SERVICE.

I WOULD SUGGEST THAT SUCH A FOCUSED EFFORT TO DEVELOP AND DEMONSTRATE DEMAND MANAGEMENT TECHNIQUES AND TECHNOLOGIES IS ALSO NEEDED AT THE FEDERAL LEVEL. FEDERAL DEMONSTRATION PROGRAMS IN SUCH INNOVATIVE APPROACHES TO DEMAND MANAGEMENT AS ELECTRONIC

ROAD PRICING AND INTELLIGENT HIGHWAY AND VEHICLE SYSTEMS ARE NEEDED TO DEMONSTRATE THEIR FEASIBILITY UNDER A VARIETY OF CONDITIONS.

IN MINNESOTA, WE ARE CONCENTRATING ON THE WORD SERVICE AND A FAMILY OF VEHICLES APPROACH IN IMPLEMENTING SYSTEM AND DEMAND MANAGEMENT. GETTING PEOPLE OUT OF THEIR AUTOS IS NOT EASY. WE ARE A NATIONAL LEADER IN THE PROMOTION OF VAN POOL AND RIDE SHARE PROGRAMS. WE HAVE CREATED A "SANE" LANE ON ONE OF OUR BUSIEST EXPRESSWAYS. ONLY VEHICLES WITH TWO OR MORE PASSENGERS MAY TRAVEL ON THE "SANE" LANE. WE ARE ALSO INCORPORATING HIGH OCCUPANCY VEHICLE LANES INTO MANY OF THE PLANS FOR OTHER FREEWAYS IN URBAN AREAS. "HIGHWAY HELPERS" PATROL OUR BUSIEST FREEWAYS TO ASSIST STRANDED MOTORISTS. THIS PROGRAM HELPS TO ALLEVIATE THE CONGESTION CAUSED BY DISABLED VEHICLES.

THE EFFORTS I HAVE JUST MENTIONED ARE SHORT TERM STRATEGIES FOR SAVING FUEL AND FOR MINIMIZING ENVIRONMENTAL AND TRANSPORTATION SERVICE IMPACTS. WHILE THESE ROAD-DIRECTED STRATEGIES ARE ESSENTIAL, ALTERNATIVE FUELS AND VEHICLE IMPROVEMENTS ARE THE LONG RANGE ANSWER TO CLEAN AIR AND ENERGY INDEPENDENCE.

MR. CHAIRMAN, IN CLOSING I WOULD LIKE TO EMPHASIZE SEVERAL IMPORTANT POINTS. AS I STATED BEFORE, SOLVING OUR NATION'S ENERGY DILEMMA WILL TAKE A SERIOUS AND DEDICATED EFFORT. THE FEDERAL GOVERNMENT MUST LEAD IN ESTABLISHING A LONG-TERM

DIRECTION FOR TRANSPORTATION AND ALTERNATIVE ENERGY USE. THE FEDERAL GOVERNMENT MUST ENCOURAGE AND SUPPORT RESEARCH INTO ALTERNATIVE FUELS AND NEW TECHNOLOGY. RESEARCH IS ALSO CURRENTLY UNDERWAY TO MOVE US BEYOND THE INTERNAL COMBUSTION ENGINE INTO EXCITING ELECTRIC AND AUTOMATED VEHICLE AND ROADWAY SYSTEMS. WE MUST KEEP ALL FEASIBLE OPTIONS OPEN FOR DISCUSSION AND INVESTIGATION.

SOLVING OUR AIR QUALITY AND ENERGY CONSERVATION PROBLEMS ALSO REQUIRES THE COOPERATION OF THE PUBLIC AND PRIVATE SECTORS. PARTNERSHIPS AMONG GOVERNMENT, BUSINESS, CONSUMERS AND THE TRANSPORTATION COMMUNITY ARE CRITICAL TO ADDRESS THE ISSUES AT HAND. THESE VARIOUS INTERESTS MUST COME TOGETHER TO DEVELOP COMMON ENERGY GOALS AND OBJECTIVES. BY WORKING TOGETHER WE CAN DO A BETTER JOB OF IDENTIFYING ALTERNATIVES AND RECOMMENDING PRIORITIES FOR FUTURE STUDY AND USE.

MR. CHAIRMAN, I WANT TO THANK YOU FOR PROVIDING ME WITH THIS OPPORTUNITY TO SPEAK BEFORE YOU TODAY. THE SUBJECT OF TODAY'S MEETING AND THE ACTIONS OF THIS SUBCOMMITTEE WILL HAVE AN IMPORTANT IMPACT ON FUTURE TRANSPORTATION, ENVIRONMENTAL AND ENERGY CONSERVATION STRATEGIES. PLEASE REMEMBER TO KEEP THOSE OF US FROM THE TRANSPORTATION COMMUNITY INVOLVED IN YOUR ACTIVITIES. I WISH YOU SUCCESS IN YOUR DELIBERATIONS. THANK YOU.

Testimony Regarding Electric Vehicles
Submitted to the
Senate Energy and Natural Resources Committee
Subcommittee on Energy Research and Development

June 19, 1989

This statement is submitted on behalf of the Southern California Edison Company and the Los Angeles Department of Water and Power. We appreciate this opportunity to submit our views on the status of current and future use of alternative motor vehicle fuels, and commend the Subcommittee for its interest in this important issue.

Our testimony is directed toward the need for incentives to stimulate the commercialization of electric vehicle technology. The lack of currently-demonstrated commercial applications of this technology is a substantial obstacle to the creation of a market for electric vehicles. We urge the Subcommittee's consideration and support for initiatives designed to accelerate the introduction and widespread use of electric vehicles.

The Need for Electric Vehicles

More than eighty metropolitan areas of the United States do not meet Environmental Protection Agency standards for ozone. Non-attainment of standards for ozone and carbon monoxide is caused in part by mobile source emissions. As the urgency of complying with the Clean Air Act and ozone non-attainment standards increases, the need for emission-free transportation sources will also increase.

The single most effective alternative for reducing transportation sector emissions is the electric vehicle (EV). A recently commissioned study comparing five alternatively fueled vehicles, including electric vehicles, demonstrated that of the relatively near-term alternatives to conventional gasoline powered vehicles, EVs are by far the lowest emission vehicles. Replacement of one percent of the vehicles registered in the United States today with electric vehicles would reduce emissions by 160,000 tons per year.

Air quality problems are particularly acute in southern California. To bring the area into compliance with the standards of the existing Federal Clean Air Act, the South Coast Air Quality Management District (AQMD) has proposed a plan that has received considerable national attention. Once fully approved, the plan would be implemented in three stages ("tiers"). Full implementation of already known control technologies is to take place over a five year time frame (Tier I). As part of this measure, new requirements for the purchase of "low emission" vehicles would be imposed, initially in 1991 on public vehicle fleets, and after 1993 on private vehicle fleets. Significantly, the air quality plan does not specify that electric vehicles must be substituted for conventional gasoline-powered vehicles. Alternative fuel technologies that are closest to commercial acceptance, whether methanol, ethanol, CNG or LPG, may be chosen. None of these technologies is as attractive from an air quality standpoint, but they are now considered more likely to be commercially available within the first five-year time frame.

In Tier II of the AQMD plan, significant advancement of today's technologies will be required over the next ten years. Use of low emission vehicles will be mandated in 40% of all passenger vehicles, 70% of all freight vehicles and in 100% of transit vehicles currently powered by diesel fuel. In Tier III, technological breakthroughs occurring over the next twenty years will be relied upon to require conversion of all vehicles to extremely low emission fuels. At the present time, electric vehicles are the only vehicles that would satisfy this requirement. Compliance with southern California's ozone requirements will ultimately require an all-electric transportation system, but not until the next century.

Without initiatives to stimulate the EV market, suitable electric vehicle options are extremely unlikely to be available to meet the ambitious goals of the AQMD plan or any similar plan, be it in southern California or elsewhere in the country. Significantly, the outlines of the President's clean air proposals also emphasize increasing reliance on alternatively fueled vehicles in the 1995-2004 timeframe. Like the California plan, the President's proposals also will not mandate the use of electric vehicles, but rather will allow for choices from among several alternate fuels.

If electric vehicles are to be available in commercial quantities to meet the targets included in the President's proposals, steps must be taken now to facilitate EV commercialization. The California AQMD plan expressly acknowledges that to "achieve Tier II objectives for transportation sources [within ten years], measures to accelerate penetration of electrified/alternately fueled vehicles into the vehicle fleet will be required." Until the electric vehicle market is fully developed, consumers may tend to place undue reliance on other alternative fuel sources, thereby making it ultimately more difficult to reach the ozone reduction goals of the AQMD plan, the President's proposals or similar programs.

Electric vehicles also offer important benefits in terms of energy security. With over 160 million vehicles registered in the United States, substitution of only one percent of that total with electric vehicles would save over 60,000 barrels of oil per day, with corresponding savings in terms of the U.S. balance of trade deficit. EVs offer the opportunity to reduce the United States' dependence on unreliable foreign sources of petroleum products. Substitution of conventionally-fueled vehicles with electric vehicles offers one important means of insulating the national economy from the shocks occasioned by any disruption in the oil marketplace. The susceptibility of the oil market to disruption with its impact on consumers is seen all too clearly in the aftermath of the Exxon Valdez accident.

Barriers To Development Of An Electric Vehicle Market

The advantages of EVs described above -- their contribution to a cleaner environment and greater national and economic security derived from greater energy security -- currently relate more to "general public benefits" than to benefits likely to be realized by individual consumers of electric vehicles. Unless or until consumers are convinced that the product meets their individual needs, or until public policy dictates a change in consumer preferences, EVs, despite their public benefits, are not likely to displace conventionally-fueled vehicles. Until public policy requires a change in consumer habits, such as the changes that may be required in California under the AQMD plan and in other areas, and/or the product itself better meets consumer preferences, EVs, like other alternately-fueled vehicles, may enjoy only limited market acceptance.

Quite obviously, public policy, again as evidenced in southern California, is in transition. As increasing emphasis is placed on air quality improvement, those alternately fueled vehicles which best meet consumer preferences and are most able to cost-effectively comply with new public policy dictates will have the best chance of market acceptance. The benefits of EVs -- the technology most consistent with the need to reduce mobile source emissions; the technology able to provide the most direct and effective means to cutting transportation sector emissions -- cannot be realized soon unless consumer acceptance is also addressed and accelerated.

The type of initiative needed to address the problem of consumer acceptance has a parallel in the automotive industry: "seeding" the market with a new product. Through "seeding," the market is shown the product, enabling consumers to become familiar with it and leading to improvements in the product. But those private manufacturers now interested in EVs are not in a position to carry out this seeding on their own -- they do not have a base of manufactured vehicles available, and they do not have any other profit centers to draw on to cover the cost of producing the necessary vehicles. Thus, they are not in a position to perpetuate a new product with an existing product.

Moreover, potential manufacturers have been unwilling to make the investments necessary in production facilities without stronger indications of consumer demand for EVs. In turn, the lack of production facilities has kept the per vehicle cost high compared to comparable gasoline-powered vehicles. And without a production model, which is expected to achieve significant economies of scale and thereby lower costs, consumers are unwilling to pay the price per vehicle. Therefore, consumers are unable to evaluate the performance of EVs in actual fleet use. Fleet operators and the general public simply will not commit to the use of a large number of EVs until they are satisfied that EVs are reliable and cost competitive. As a result, EVs are not in commercial production in the United States today.

To resolve this "Catch-22" situation, incentives to advance EV commercialization are needed. Without efforts to encourage market acceptance of EVs, the benefits of this important technology, both in terms of air quality improvement and energy security enhancement, may never be realized.

The Current State Of Technology Development

The electric vehicles closest to the point of commercialization today are powered by conventional lead acid batteries. With this technology, a full sized electric van has been designed and is in prototype production undergoing Federal Motor Vehicle Safety Standards (FMVSS) tests and limited testing in commercial fleets.

Near term technology, i.e., technology expected to be available within the next five years, will rely on nickel-iron and sodium-sulfur batteries, that will increase the projected vehicle range to as much as 150 miles between recharges. The electric van now equipped with a lead acid battery and in testing can be retrofitted with advanced battery technologies when they become available. Such a range can meet the daily needs of over 80% of drivers of commercial fleet vehicles in the United States.

The urban areas to which EVs are most suited for their initial introduction are the same areas of the country in which air quality degradation is most severe, and where the environmental benefits of the emission-free EVs are most needed. Fleet operations in these urban areas are the natural first market for EVs. The 60 mile range of the vehicles between recharges is suitable for many urban fleet applications. In fact, as much as 50% of fleets used in major urban areas travel only 60 miles in any given work day. Also, systematized fleet maintenance, replacement and procurement practices provide a means to introduce EVs into existing fleets as older conventionally-powered vehicles are retired with less disruption to the overall fleet. Because of their low maintenance requirements and low energy costs, EVs can present an attractive alternative to currently available vehicles.

Limited Federal Funds Should Best Be Utilized To Stimulate Electric Vehicle Commercialization Through A Program Of Direct Incentives

In enacting the Electric and Hybrid Vehicle Research, Development and Demonstration Act in 1976, the Congress established the development of electric vehicles as a national priority. In the intervening years, efforts under this program have supported important research and development work. Much of that federal effort has been devoted to work on improving electric vehicle battery technologies.

While these R&D efforts have resulted in important advances, we are still several years away from advancing battery technology beyond the conventional lead acid configuration. In light of the rapidly changing focus of public policy toward achieving the air attainment objectives of the Clean Air Act, and to ensure that EVs are available as early as possible to achieve those goals, the federal focus should be expanded to address directly the obstacles to widespread commercial use of EVs. Improvements in battery technology are essential to the ultimate commercial acceptance of electric vehicles. But by stimulating the creation of a market for electric vehicles, the government can also encourage earlier consumer acceptance as well as the infusion of greater amounts of private research and development dollars into battery programs.

In view of existing budget constraints, the federal government simply is not in a position to devote as much money as is needed to significantly advance battery development efforts. What is needed is a larger infusion of private research and development dollars. Yet battery research is effectively stymied today by the lack of commercial prospects for electric vehicles. The private sector tends to regard battery programs as research projects, not as production projects. Private companies have no motivation to put large amounts of their own funds into research projects because there is no current outlet for the battery product. An important outgrowth of a national initiative to develop an EV market will be the creation of an outlet for EV battery products. As a result, a market-driven mechanism will exist to pull private R&D funds into battery research, and thereby advance the time when enhanced battery technologies will be commercially available.

Recommendation for a National Electric Vehicle Initiative

Multi-year funding for an electric vehicle commercialization incentive program should be provided as part of any package of incentives to encourage the development of an alternative vehicle fuels capability in the transportation sector. An EV commercialization program would serve as a clear signal to the marketplace -- EV producers and potential consumers -- that this nation is serious about realizing the important environmental benefits that EVs offer.

Some of the principles around which a national electric vehicle commercialization initiative should be organized are:

- A requirement for cost-sharing by private sector participants, with limitations on the percentage of the per vehicle cost that may be paid by federal funds;
- A program targeted to those non-attainment areas with the most significant need for air quality improvement;
- An effort directed not to ultimate purchasers but to potential manufacturers, in order to develop a continuing manufacturing capability;
- A multi-year authorization, to provide stability in the program and to permit the integration of advanced battery technologies and other technology improvements into a commercially acceptable vehicle or vehicles; and

- An ultimate goal of driving down the cost of EVs, calculated on a life-cycle basis, to be on a parity with the life cycle costs of a conventional internal combustion engined vehicle.

Conclusion

High prices as well as lack of actual on-the-road experience are keeping EV demand below the level necessary to justify manufacturers in establishing production facilities. Without carefully crafted federal incentives, EVs will continue to be produced in only very small numbers at prohibitive costs. Unless a program to spur commercialization is instituted, this nation will continue to be denied the primary benefits of EVs: air quality improvements and reduction in reliance on foreign sources of petroleum.

We urge the Subcommittee to consider the need for federal incentives to encourage the widespread use of EVs as part of its consideration of appropriate legislation in the days ahead.

NPGA
National PROPANE GAS Association
1235 Jefferson Davis Highway • Arlington, Virginia 22202 • 703/979-3560

June 6, 1989

STATEMENT OF THE
NATIONAL PROPANE GAS ASSOCIATION
BEFORE THE
SENATE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. Chairman: On behalf of the NAtional Propane Gas Association, I am pleased to submit these comments for your hearing on Alternative Motor Fuels. The National Propane Gas Association (NPGA) represents over 4,000 members who comprise all aspects of the LP-gas industry including marketers, suppliers, transporters, producers and equipment manufacturers. Propane is the most widely used alternative motor fuel in the world today and NPGAs members are keenly interested in current alternative fuels legislation before the Congress.

Any consideration of alternative motor fuels must address two important factors: 1) Ability of the alternative fuel to help reduce air pollution below that of gasoline and diesel fuel; and 2) Ability of the alternative fuel to make this country more secure and less dependent on unreliable sources of energy. We believe that propane or LP-gas can meet both parts of that test.

LP-gas, primarily propane and butane, is composed of light hydrocarbons derived from natural gas through a fractionalization process (about 68% of supply) and from crude oil refining (about 32% of supply). Approximately 88% of propane supplies are domestically produced with 75% of the imports coming from Canada. It is therefore a very secure energy supply.

Widely used in water heating, space heating, crop drying and other agricultural purposes, LP-gas also fuels over a million vehicles including cars, trucks and industrial forklifts.

SUPPLY AND MARKETS SERVED

According to the Energy Information Administration, in 1987 the U.S. produced about 18.9 billion gallons of LP-gases of which 12.6 gallons were propane, the rest being largely butane and iso-butane. Imports of LP-gases in the same year totaled about 2.5 gallons, of which 1.4 billion gallons came from Canada and about 264 million gallons came from Mexico and the U.K.

Excluding export sales, the principal uses of LP-gas for 1987 were:

Residential and Commercial	5.7 billion gallons
Chemical	6.3 billion gallons
Farm	1.5 billion gallons
Industrial	1.3 billion gallons
Engine Fuel	718 million gallons
Utility Gases	188 million gallons
Other	500 million gallon

The large volume of chemical use of LP-gas principally propane, are due to the fact that as prices soften in the propane market, chemical manufacturers find it economically advantageous to buy large volumes of propane rather than use alternatives of ethane and naphthas. When prices firm up, these same purchasers will switch back.

Recent trends in LP-gas sales have shown that as the residential and commercial markets decline, due in large part to energy conservation and the introduction of higher efficiency appliances, chemical purchases have increased. The trends also show that internal combustion sales have declined largely as a result of the decline in gas prices since 1981.

Supplies will be enhanced with the addition of butane as a result of the lowering of vapor pressures of gasoline. Ninety-five percent of butane used in the U.S. currently goes into gasoline. Today, butane is being exported from both the West and East Coast to Latin America and the Caribbean. We believe that this is unconscionable considering the pollution problems facing this country. It seems that this country's short term strategy is to import methanol at the same time that we are exporting domestically produced gas liquids.

REAL WORLD SCENARIO - THE IMPACT OF LP-GAS

Translating data into a real life situation brings focus to the impact LP-gas can have on the fleet market, particularly for the non-attainment areas.

Statistics indicate that there is a total U.S. truck registration of almost 19 million. Of this number, approximately 8.5 million are in fleet use. As stated before, we believe that LP-gas and natural gas are particularly suited for that market characterized as fleets which return to a central base every night and which consist of vehicles that are five years old or younger. We calculate this market to be about 2.1 million trucks or 25% of the total U.S. fleet market.

School buses represent another prime market for propane use. School bus fleets from Florida to Oregon have been converted to propane. In this market, there are an estimated 352,434 school buses on which about $5.75 billion per year is spent by school districts nationwide. It has been proven that propane can cut costs, extend engine life and reduce maintenance on these vehicles. In addition, school districts have approximately 11,000 underground storage tanks susceptible to leaks which compound the problem of contaminated water.

Looking at the question of adequate supply, we estimate that an additional 4.0 billion gallons of U.S. produced supply will be available by 2004. Adding Canadian surplus production and only 50% of the other world-wide surplus we calculate 8.0 billion gallons of additional supply will be available during the next 15 years. If we add the gas liquids planned for export from the Alaska North Slope, the additional supply grows to 11.0 billion gallons. This scenario does not include any of the 5.3 billion gallons currently going into the chemical market simply because the price is cheap.

In summary, current and projected supply is more than adequate to operate a minimum of 10 million vehicles on LP-gas. Mandating alternative fuels use would direct these supplies into the critical non-attainment areas where fleet vehicles are most numerous. Even more should be done, such as research and development, to encourage use of this premium fuel rather than blindly go along seeing it used as junk feedstock for petrochemical plants or, even worse, for export.

POLLUTION CONTROL

Mr. Chairman, our industry supports legislation which contains balanced and reasonable means for dealing with air pollution from internal combustion engines. We believe that LP-gas can play a key role in helping our nation's cities attain the air quality goals of the Clean Air Act. Among the many benefits of LP-gas use in both motor fuel and industrial applications are:

- Reduced emissions on vehicles having no or limited emission control devices;
- Reduced emissions on vehicles with emission control devices;
- A closed fuel system which eliminates evaporative emissions;
- No contamination of groundwater or water systems from either above or below ground storage tanks
- Long lasting emissions control devices due to the clean burning characteristics of this gaseous fuel;
- Reduced emissions from industrial boilers and process heaters currently using oil.

Obviously, most American cities have failed to meet the requirements of the Clean Air Act. Already some areas are losing federal funding and incurring construction bans as sanctions are imposed for failure to comply. We believe the use of LP-gas offers a viable solution to these kinds of problems.

Attached to our statement are the results of emission tests of LP-gas powered vehicles conducted by EPA's labs in Ann Arbor, Michigan and Denver, Colorado. These tests show clearly and dramatically that a light duty Ford LTD passenger car's emissions can be reduced by converting to LP-gas. Using EPA data you'll note that this vehicle's gasoline hydrocarbon emissions were already 50% below the 1988 standards, 76% below the carbon monoxide standards and slightly higher on nitrogen oxides than the standard.

Despite the already clean emissions on gasoline, the hydrocarbon emissions when tested on propane were 73% below the standard and 50% below gasoline (using California Air Resources Board reactivity factors). The carbon monoxide was 93% below the standard and 70% better than gasoline and nitrogen oxides were 39% below the standard and 43% better than gasoline.

We believe that LP-gas is the perfect fuel for fleet users. It has proven ideal in metropolitan fleets by bakery companies, delivery trucks, transit and school buses and taxi fleets.

Local delivery vehicles, taxis and bus fleets are known for their periods of curbside idling during pick-up, stop-offs, discharging passengers, etc. It is during these times of idle and in stop-and-go of city traffic, that noxious emissions reach peak levels. We believe that LP-gas is the ideal solution for this vexing problem faced by all metropolitan areas.

Many light and medium duty fleet vehicles on our roads today still lack meaningful emissions controls. Since it will be 5-10 years, if then, before any substantial number of low-emission vehicles will be operating, legislation which facilitates retrofit of these older, high emitting vehicles to gaseous fuels (LP-gas and natural gas) only makes sense.

Gaseous fuels are the only alternative available now. And now is when we have the problem. If the mandates of the Clean Air Act are to be met, this country can't afford to wait for a solution to the numerous problems of methanol including supply, infrastructure, distribution, costs, user acceptance and aldehyde emissions.

HARDWARE AND SAFETY CONSIDERATIONS

There are four basic components required for the conversion of a gasoline engine to operate on propane: the fuel tank, lockoff valves, and filters, the converter, and the carburetor.

LP-gas motor fuel tanks must be constructed to codes and specifications established by the U.S. Department of Transportation and the American Society of Mechanical Engineers (ASME). Propane containers have survived nuclear tests in the Nevada desert and crash tests in Holland.

ALTERNATIVE FUEL OPTIMIZATION

We strongly endorse the concept of optimization of the various fuel alternatives for those applications best suited. For example, an extensive infra-structure is already in place to service the private automobile market with gasoline. To duplicate that system for the sole purpose of having alternative fuel is neither cost-effective nor necessary.

On the other hand, the average fleet vehicle travels more miles than a private automobile, consumes two-and-half to three times the volume of fuel, and employs less sophisticated emission control devices which greatly reduce air quality. For this market, central fueling locations for propane are cost effective.

Realistically, LP-gas is not the panacea to the U.S. air pollution problem. No singular fuel is. Supply simply would not be adequate. We see the following scenario:

- Gasoline and methanol for private vehicles
- Diesel in areas without attainment problems
- Gaseous fuels (LP and natural gas) for fleets and inner city markets.

Methanol may be the fuel best suited for the general public over the long pull. But until the problems are resolved the benefits are currently elusive and speculative. Until the benefits of methanol can be experienced the gaseous fuels can be - if nothing else - a transitional fuel because it's here now.

Should other fuels or sources of energy claim a rightful role later on, so be it. Legislation should foster a free market environment for competing fuels.

CONCLUSION

Mr. Chairman: We urge the Senate Subcommittee on Energy Research and Development to explore the advantages of LP-gas use as an alternative fuel. The National Propane Gas Foundation, a non-profit, charitable research foundation funded through voluntary contributions from our members, has engaged in meaningful research which has had real world applicability. Given our success with limited resources, we believe that the Department of Energy, for a relatively modest sum, could fund useful research into ways that LP-gas' proven technology can be put to use.

We also do not support the view of the Department of Energy that one replacement fuel must be found for all vehicles. We should learn from Brazil's disastrous attempt to change the system completely to alcohol fuels. There are many reasonable choices that will work together to help achieve energy independence.

In addition to research and development, some options for alternative fuels include:

- Elimination of the federal excise tax of 9 cents per gallon on LP-gas. At a minimum a reduction to a BTU parity with that of gasoline.
- Special incentives to van pool operators using LP-gas or other low-emitting fuel.
- Making petroleum violation escrow funds available through the state to support state incentive plans.

- Stipulating specifically "LP-gas" in the definition of alternative fuels in legislation.

Mr. Chairman, we encourage you to allow a wide variety of choices in drafting alternative fuel legislation. The marketplace will respond. We believe that the result will be lower compliance costs, faster response time, and greater public acceptance. If you set the standard and keep the market open, we believe that LP-gas will thrive and play a key role in cutting air pollution and in reducing reliance on gasoline and diesel fuels.

Respectfully submitted,

James N. Burroughs

James N. Burroughs
Vice President, Government
Relations and General Counsel

JNB/sb

EMISSION TEST RESULTS

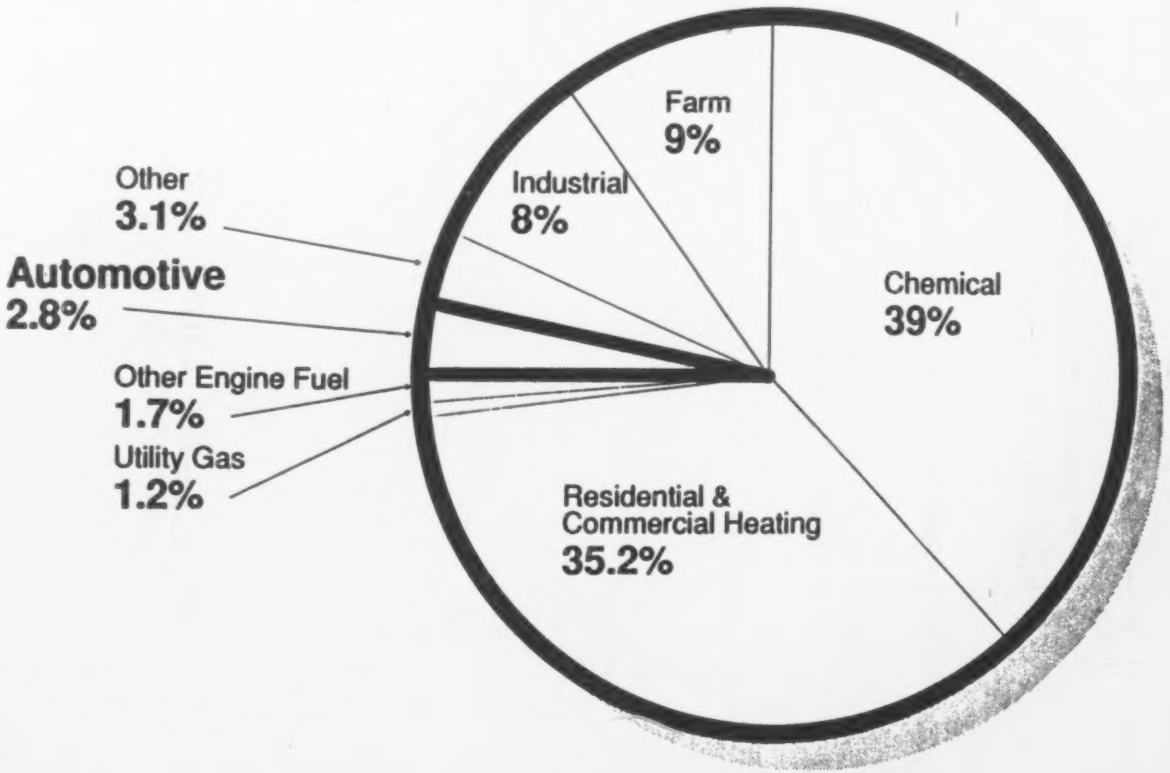
PETROLANE 1988 FORD CROWN VICTORIA (T.N.)

TEST SITE: ENVIRONMENTAL PROTECTION AGENCY (EPA) ANN ARBOR, MI.

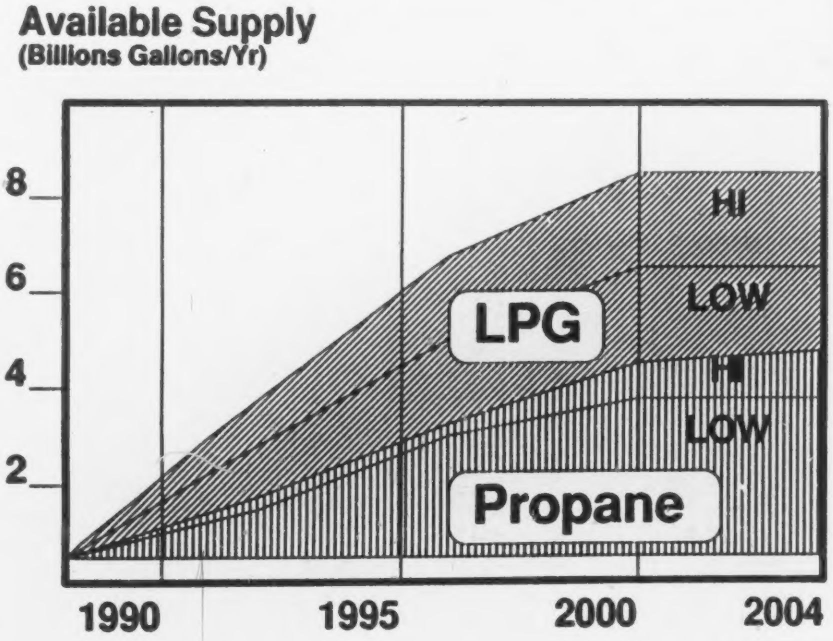
	THC TOTAL HYDROCARBONS		CO CARBON MONOXIDE	NOx NITROGEN OXIDES
GASOLINE STANDARD* GM/MI	.41		3.40	.70
GASOLINE BASELINE (INDOLENE)	.22		.79	.75
	GROSS	NET		
COMMERCIAL PROPANE (LPG)	.26	.11	.24	.43
% BELOW STANDARD	37%	73%	93%	39%
%BELOW GASOLINE	(18%)	50%	70%	43%

* 1988 FEDERAL STANDARD AND ALTERNATE CALIFORNIA STANDARD

Merchant Market Sales of LPG in the U.S. 1987



U.S. Auto - LPG Supply & Potential Vehicle Population



2004

Vehicles (Millions)	Fuel (%)
6.5	5.4%
5.2	4.2%
3.6	3.0%
2.9	2.4%
0.33	0.4%

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June 22, 1989

The Honorable Wendell Ford
Chairman
Senate Subcommittee on Energy
Research and Development
Committee on Energy and Natural
Resources
312 Senate Dirksen Office Building
Washington, DC 20510

Re: June 8, 1989 Hearings on Alternative Motor Vehicle Fuels

Dear Chairman Ford:

Attached is a **Resolution on Natural Gas Vehicles** adopted by the Executive Committee of the National Association of Regulatory Utility Commissioners on March 1, 1989. The NARUC would appreciate that it be attached to the record of the June 8, 1989 hearings on Alternative Motor Vehicle Fuels.

Thank you for your attention.

Sincerely,

Paul Rodgers
Paul Rodgers
General Counsel

Julienne Wood
Julienne Wood
Assistant Director
Congressional Relations

Enclosures

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*Member of the Executive Committee of the Association.

Resolution on Natural Gas Vehicles

WHEREAS, Air quality is a problem of major concern throughout the nation; and

WHEREAS, The Federal Clean Air Act mandates regions to meet the national ambient air quality standards for ozone and carbon monoxide before December 1987, but 76 metropolitan areas do not meet the ozone standard, and 40 areas do not meet the carbon monoxide standard; and

WHEREAS, Motor vehicle emissions are a major cause of much of the nation's air pollution; and

WHEREAS, Natural gas vehicles (NGVs) are the cleanest hydrocarbon fueled vehicles and most economical of all the vehicles available, and NGVs produce only small amounts of carbon monoxide, reactive hydrocarbons and nitrogen oxides; and

WHEREAS, NGVs also cut down on gases, such as carbon dioxide, that contribute to what has been called the greenhouse effect; and

WHEREAS, Anticipated advancements in technology will make NGVs even cleaner; and

WHEREAS, Natural gas, unlike other alternative fuels, is available in plentiful supply and at a reasonable cost; and

WHEREAS, Natural gas utilities have the expertise and experience to help develop the needed new technology and guide its implementation; now, therefore, be it

RESOLVED, That the Executive Committee of the National Association of Regulatory Utility Commissioners, assembled at its 1989 Winter Meeting in Washington, D.C., declares that legislation is needed to encourage the development and application of natural gas vehicles.

Sponsored by the Committee on Gas
Adopted March 1, 1989

CLEAN
FUELS
DEVELOPMENT
COALITION

June 16, 1989

Mr. Daryl Owen
c/o The Honorable J. Bennett Johnston
U.S. Senate
Washington, D.C. 20510

Dear Mr. Owen:

As you may know, this past Tuesday President George Bush visited the ethyl tertiary butyl ether (ETBE) testing facility at the University of Nebraska in Lincoln. In his speech (see enclosure) he referred to the administration's clean air proposal, which includes oxygenated fuels, such as ethanol and ETBE, as an air pollution reduction strategy. To quote the President: "ETBE isn't quite a household word--but it may just become one, based on what I've seen today."

All this would never have happened if it were not for you and the tremendous congressional support for the alternative fuels industry over the past years. I would like to take this opportunity to thank you once again for all of your help. Oxygenated fuels can play a significant role in reducing the nation's air pollution. With your help they will expand their already important role in the future.

As the clean air debate continues and these fuels are examined, please call on us if we can supply information or other assistance.

Sincerely yours,

Doug Durante

Douglas A. Durante
Washington Representative

DAD\fln

Enclosures

THE WHITE HOUSE

Office of the Press Secretary
(Lincoln, Nebraska)

For Immediate Release June 13, 1989

REMARKS BY THE PRESIDENT
AT THE UNIVERSITY OF NEBRASKA

Bob Devaney Sports Center
Lincoln, Nebraska

3:25 P.M. (CDT)

THE PRESIDENT: Thank you, ladies and gentlemen. (Applause.) Thank you very, very much. Kay, Governor Orr, thank you so much. Thank all of you -- Governor Orr, distinguished leader of this state, for those kind words, that warm introduction. My thanks also to Dr. Roskens, Chancellor Massengale, Chairperson Hoke, and all the other officials at this wonderful institution. And I also want to thank Dr. Peter Jenkins, my tour guide, who runs the Center for Engine Technology here at the University of Nebraska. And also my special thanks to three members of my Cabinet, Secretary Watkins, Secretary Lujan, and Secretary Clayton Yeutter, for joining me here today.

I hope that this symoblizes to all of you the importance that we place not just on the research that's going on here at the University, at this wonderful University, but the importance of agriculture and Nebraska -- the two go together. And we're here to salute you. (Applause.)

And Secretary Yeutter, as we've heard, is a graduate of this fine school, and let me put it this way -- I'm delighted to have a Cornhusker in my Cabinet. (Applause.)

And we have several members of Congress traveling with me today -- your own Doug Bereuter is here, Congressman from Nebraska, someplace over here. (Applause.) And then three Wyoming officials, Senator Wallop, Senator Alan Simpson, and Congressman Craig Thomas over here. Maybe they'd stand up. (Applause.)

And lastly, I'd like to thank the band, the Air Force Band from Offet -- first-class music. Anybody who can keep you all awake for two hours must have something going for them. So thank you, sir, thank you very much. (Applause.) Thank you so much for being with us.

I would have made it here a few minutes earlier, but we've been driving around looking for a parking place. (Laughter.) Actually, I've come from Dr. Jenkins' lab, where I got a short seminar on engine testing and alternative fuels -- fascinating, trail-blazing work. You can't help but see it to realize that we have a window to the future. And I'm a believer in alternative fuels and conservation. This winter I'm putting windmills in Washington. (Laughter.) Henceforth, hot air is going to heat the entire city. (Applause.)

Let me tell you a bit about the path-breaking work that I've just seen in this engine lab. They've got two cars hooked up to emissions monitors -- one running on gasoline, the other on new ethanol blend that they're working on. And the results are impressive. The proof is right there before you in the readout: the car runs cleaner on the ethanol mix.

And they're confident down there. I asked about performance and they told me to take a car out on a test drive. I don't do a lot of driving these days, so I'm not sure that I'm the best judge. But I enjoyed the ride. And it had a lot of pickup, certainly got more pickup than the 14,000-pound limousine sitting outside this place. (Laughter.)

Many of you know that yesterday I announced some sweeping changes to the Clean Air Act -- the first amendments to that landmark legislation in more than a decade. And whether you live in the city, or in the country, or on a farm, or near a factory -- the changes that we're calling for are going to improve the quality of the air we breathe and, therefore, the quality of life for all Americans. (Applause.)

This is a nation rich in the majesty of nature. In the past 24 hours, I've seen some of the magnificent sights that this great land has to offer. Nature renewing itself in Yellowstone after those devastating fires. The Tetons rising up, postcard-perfect, from the Wyoming plateau. Sights like those make me all the more determined that this nation dedicate itself to the restoration and renewal of our natural heritage.

My approach is driven by a new kind of environmentalism, built on five principles: harnessing the power of technology and the marketplace; promoting state and local environmental initiatives; encouraging a common international effort; concentrating on pollution prevention; and strict enforcement of environmental standards. Today, I want to focus on the first of these five -- on ways that we can harness the power of technology in service to our environment.

The work you're doing here puts Lincoln on the leading edge of that effort. Alternative fuel is going to help us reconcile the automobile to our environment.

And right now, 81 American cities exceed federal clean air standards. Expanded use of alternative fuels is a key element in my plan to guarantee that 20 years from now, every American, in every city across this country, will breathe clean air. (Applause.)

Alternative fuels are going to help us get there. In the nine urban areas with the worst ozone pollution, we're requiring a million clean-fuel vehicles on the street by the year 1997. Our clean air plan also calls for cities with the worst carbon monoxide problems to use oxygenated fuels to cut emissions during peak winter months.

And our plan preserves flexibility. The urban areas targeted for cleanup can opt out of requirements -- provided they find other ways to make equivalent cuts in pollution levels. And although we're proposing some tough pollution control measures, we're going to develop ways to allow automobile manufacturers and fuel companies to trade emissions reduction credits among themselves -- so long as the overall emissions standard is met. And our goal -- clean air -- and we're going to achieve it in the most efficient way possible, but make no mistake about it, we are going to achieve our goal. (Applause.)

I came out to the University of Nebraska to get a first-hand look at one of the clean air technologies of tomorrow -- an alternative fuel called ETBE, made from ethanol and Nebraska corn. I thought I left all those acronyms behind me in Washington, incidently. ETBE is short for Ethyl Tertiary-Butyl Ether. Maybe the acronym isn't so bad after all. (Laughter.)

But ETBE isn't quite a household word -- but it may just become one, based on what I've seen today. Right now, ethanol-blend fuels account for only a fraction of America's overall gasoline consumption -- about eight percent. And that's going to change in the years ahead. Gasohol, ETBE, natural gas-based fuels like methanol, CNG, and MTBE -- all are going to play a role in a transition to cleaner, more efficient engines.

Cutting auto exhaust is an effective avenue to cleaner air. Motor vehicles produce about two-thirds of all the carbon monoxide emissions, and about 40 percent of all ozone pollution -- chemical threats to our environment that we have all had to live with.

And we're learning every day that pollution respects no borders. There's no safe haven from the damaging long-term effect of chronic environmental abuse. Exhaust pollution isn't just a big city problem anymore. We know it's time to cut exhausts, and the question then is how?

We shouldn't have to choose -- in this great country of ours we shouldn't have to choose between clean air and continued progress, between sound ecology and sustained economic growth. The answer isn't to shut off our engines and throw away our keys. That's a horse-and-buggy solution to a 21st century problem. And we can do better than that.

We've got to follow your lead -- push the envelope -- push forward technologies that promise cleaner fuels for the future. And there is more the automobile industry can -- and will -- do. But it's time now to produce cleaner fuels our cars will burn in the future.

Let me tell you just a little of what I learned in your lab. Results so far show that gas blended with ETBE additive lowers environmentally harmful emissions and increases engine performance. That's a promising combination. Think about what that means. ETBE and other alternative fuels can help us meet more stringent air quality standards -- and strengthen our domestic energy industry at the same time.

And America must work towards energy independence. You know, last year 37 percent of the oil that America consumed was imported, and so far this year, that figure's up to 40 percent.

And that trend means trouble. We worked hard to cut our consumption of foreign oil. And I will not stand by and watch our country slip back into a dangerous state of dependency -- wide open to the next oil shock from some country halfway around the world. We're not going to do that in this country. (Applause.) We've got to plan for the future now. We need secure, reliable sources of energy right here at home. Alternative fuels are an American answer.

And take a look at ETBE. It's made from ethanol, which I've long supported -- and ethanol's made from corn and other grains we grow in abundance. And that's good for American farmers -- and it's good for all American taxpayers who are now paying more than $5 billion a year in corn price supports.

Ethanol is a home-grown energy alternative. And that's good for national security -- and that's good for our trade deficit. (Applause.) And ethanol produces a fuel that burns cleaner. And that's good for our environment, just plain and simple -- good for our environment. A source of energy that's clean, abundant and made right here in the United States -- three good reasons why ethanol and ETBE are fuels of the future.

I've got great faith in farm country. Some folks might be surprised to see the kind of work going on here -- to see Nebraska leading the way on alternative fuels. But we all know the Heartland's been high-tech for a long time.

The American farmer has long been the most productive and efficient in the world. You've put food on America's table; and now you're going to help America fill up its tank. (Applause.)

The modern farmer is as comfortable talking about gene-splicing and biotechnology as he is taking the wheel off a tractor. You've been pioneering in agriculture for years. And I'm not surprised to see you moving from agriculture to energy -- and a car that runs on corn.

And Nebraska's going to make it work. These alternative fuels are going to take the market by storm. Kind of like the Big Red rolling into Norman, Oklahoma. (Applause.) You know, what you're doing here will mean cleaner air in Los Angeles and New York -- and dozens of cities in between now plagued by smog and air pollution. And that's the kind of environmental impact that can improve the quality of life -- across America and around the world.

And we won't stop with alternative fuels. In the future, we're going to be using other technological alternatives -- like biodegradables in the battle against litter and waste disposal -- to ease the threats to our environment.

Out here there's always been a strong environmental ethic. In this part of the country, taking care of the land is a way of life. It's natural. And that's why I know when I call on all Americans to make renewal and restoration our new environmental watchwords, I can count on you. (Applause.)

So let me say to all of you here today in this magnificent auditorium, stadium, area of combat -- (laughter) -- all Nebraskans should be proud of the pioneer work being done here at this great University. (Applause.) It's been a privilege for me as President of the United States to visit this great state, to listen, to learn, to catch a glimpse of progress in the making.

And for those of you in the overflow room and those along the streets from the airport into the city, let me thank you for that warm Nebraska welcome. I'll never forget it. God bless you, and God bless the United States of America. Thank you very much. (Applause.)

END 3:43 P.M. CDT

Ethanol Fuel Association
P.O. Box 9055, Boise, Idaho 83707 • (208) 322-8288

June 16, 1989

AN OPEN LETTER TO ALL ETHANOL SUPPORTERS:

President Bush, along with the Secretaries of Agriculture, Energy, and Interior visited Lincoln, Nebraska on June 13th. He made a strong statement in favor of ethanol and ETBE which was covered by "World News Tonight with Peter Jennings" of ABC-News. NBC and CBS chose to ignore the entire event.

As an association with limited resources, we are virtually helpless against the whims of the major news media but we feel strongly that our cause, when advocated by the President of the United States, was arbitrarily "left on the cutting room floor" by NBC and CBS along with major newspapers such as USA TODAY, New York Times, The Washington Post, and the Wall Street Journal.

Our customers, associates, and friends, in fact the entire Americician Public has a right to know how the President feels about ethanol.

Having expressed our displeasure, we are asking you to do the same. Call or write NBC News and CBS News and express your opinion.

We feel this action cannot not be left unnoticed by those of us who care about the ethanol industry and it´s future.

Yours very truly,

James T. Glancey
Chairman

JTG/ob